BUSINESS & PUBLICATION OFFICES
20TH AND NORTHAMPTON STREETS
EASTON, PENNSYLVANIA

EDITORIAL OFFICE
KENT CHEMICAL LABORATORY
THE UNIVERSITY OF CHICAGO

OTTO REINMUTH, *Editor*
VIRGINIA GORE, *Assistant to the Editor*
HARVEY F. MACK, *Business Manager*
CYRUS S. FLECK, *Assistant Business Manager*
B. F. GOULD, *Advertising Manager*
C. L. WELLS, *Circulation Manager*

BOARD OF PUBLICATION
R. A. BAKER, G. J. ESSELEN
T. L. DAVIS, O. M. SMITH
N. W. RAKESTRAW

DEPARTMENTAL EDITORS
R. A. BAKER, *Abstracts*
H. C. SHERMAN, *Graduate*
W. SEGERBLOM, *High School*
TENNEY L. DAVIS, *Historical*
R. E. ROSE, *Industrial*
M. M. HARING, *Undergraduate*

CONTRIBUTING EDITORS

G. A. ABBOTT	B. S. HOPKINS
B. H. BALL	J. W. HOWARD
A. P. BLACK	S. F. HOWARD
W. E. BRADT	S. W. HOYT
G. H. BRANDES	J. B. LUCAS
C. A. BRAUTLECHT	E. G. MAHIN
J. M. BRECKENRIDGE	R. N. MAXSON
B. S. BRONSON	R. K. MCALPINE
F. E. BROWN	W. MCCRORY
H. W. BRUBAKER	A. E. MCKINNEY
C. A. BUEHLER	J. P. MONTGOMERY
T. F. BUEHRER	H. W. MOSSLEY
H. A. CARPENTER	L. ONCLEY
F. E. CLARK	A. M. PARDEE
J. D. CLARK	J. L. PARSONS
A. J. CURRIER	L. E. PORTER
F. B. DAINS	F. H. PRITTIE
L. C. DAVY	E. L. QUINN
N. DIETZ, JR.	G. R. ROBERTSON
O. C. DRAKE	W. F. RUDD
A. L. ELDER	H. SCHLUNDT
W. G. EVERSOLE	G. W. SEARS
O. R. FOSTER	O. P. STAFFORD
W. FOSTER	R. E. SWAIN
J. H. GRAHAM	J. N. SWAN
G. C. GREENWOOD	A. P. SY
J. S. GUY	R. B. THOMPSON
W. A. HAMMOND	T. G. THOMPSON
E. B. HARTSHORN	R. G. TURNER
C. A. HASKEW	W. A. VAN WINKLE
C. C. HEDGES	B. A. VOIT
G. B. HEISIG	G. H. WHITEFORD
B. C. HENDRICKS	G. Y. WILLIAMS
H. N. HOLMES	L. F. WILLIAMS

FOREIGN EDITORS

F. LAMBERMONT, *Belgium*	N. PARRAVANO, *Italy*
W. LASH MILLER, *Canada*	WOJCIECH SWIETOSLAWSKI, *Poland*
F. G. DONNAN, *England*	ST. MINOVICI, *Roumania*
ATHERTON SEIDELL, *France*	SIR JAMES IRVINE, *Scotland*
K. FREUDENBERG, *Germany*	E. MOLES, *Spain*
ERNST COHEN, *Holland*	W. D. TREADWELL, *Switzerland*

H. RHEINBOLDT, *Brazil*

Entered as second-class matter, January 31, 1924, at the Post Office at Easton, Pa., under the act of March 3, 1879. Accepted for mailing at special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized January 31, 1924.

COPYRIGHT, 1937, BY DIVISION OF CHEMICAL EDUCATION, AMERICAN CHEMICAL SOCIETY

The JOURNAL OF CHEMICAL EDUCATION *is indexed in the Education Index, Industrial Arts Index, and, in part, in the Quarterly Cumulative Index Medicus*

JOURNAL OF CHEMICAL EDUCATION

for July, 1937

OFFICIAL MONTHLY PUBLICATION OF THE
DIVISION OF CHEMICAL EDUCATION OF THE
AMERICAN CHEMICAL SOCIETY

O. M. SMITH, *Chairman*
N. W. RAKESTRAW, *Secretary*
E. W. PHELAN, *Vice-Chairman*
VIRGINIA BARTOW, *Treasurer*

Volume 14, Number 7 Contains

FRONTISPIECE—HEINRICH WIELAND 301

EDITOR'S OUTLOOK 302

THE PRODUCTION OF ELECTROTYPES 303
C. E. Ronneberg

AN IMPROVED CHEMICAL HOOD 310
Eugene C. Bingham

PHENYLARSONIC ACID AS A QUALITATIVE TEST FOR TIN 312
R. H. Bullard

THE EPIGRAMS OF REMIGIUS FRESENIUS I 313
Ralph E. Oesper

DEMONSTRATION OF A NEGATIVE TEMPERATURE COEFFICIENT OF SOLUBILITY 315
L. A. Bateman and W. C. Fernelius

AN APPROACH TO THE THEORY OF IONIZATION 316
T. H. Hazlehurst

AN IMPROVED METHOD FOR IGNITING THERMITE REACTIONS 320
O. C. Klein

AN EXPERIMENT IN THE TEACHING OF HIGH-SCHOOL CHEMISTRY . . . 321
Richard Haskins, John Gavin, and E. C. Bowman

A NOTE ON THE PREPARATION OF *m*-DINITROBENZENE—A CORRECTION . 323
S. V. Shah

THE FERRIC THIOCYANATE EQUILIBRIA 324
Robert DuBois

THE USE OF STANDARD SODIUM HYDROXIDE SOLUTION FOR THE STANDARDIZATION OF POTASSIUM PERMANGANATE 326
D. L. Scoles and Joseph Rothstein

DAILY CHEMICAL ANNIVERSARIES AS A TEACHING TOOL 328
Ernest H. Huntress

HEINRICH WIELAND 344
Ralph E. Oesper

ABSTRACTS 345

RECENT BOOKS 348

TRADE ANNOUNCEMENTS VIII

Subscription Price: $3.00 per year; Canada $3.50; other countries $4.00. Single copies of issues in current year, 50c each; all other single copies, one dollar. Foreign remittances must be accompanied by International Money Order. Issued monthly.

No claims for copies of journals lost in the mails can be allowed unless such claims are received within sixty (60) days of the date of issue and no claims can be allowed for issues lost as a result of insufficient notice of change of address.

Manuscript for publication should be directed to the editor or to one of the departmental or contributing editors. Prospective authors are urged to avoid diffuse writing and to observe the forms outlined in our Notice to Authors of Papers as it appears on page 671 of the December, 1934, issue.

Coming in August

REPORT *of the* COMMITTEE *on* MINIMUM EQUIPMENT

DIVISION OF CHEMICAL EDUCATION, AMERICAN CHEMICAL SOCIETY

THE Report of the Committee on Minimum Equipment for High-School Chemistry will be published in the August issue of the JOURNAL OF CHEMICAL EDUCATION.

This is a particularly valuable article for High-School chemistry teachers, Superintendents of Schools, Boards of Education and purchasing officers.

It presents seven lists designating necessary laboratory experiments and the minimum equipment required to perform them.

These lists are based on the study of twenty-eight state lists, fifteen high-school manuals, 115 lists from high schools of large cities, and upon suggestions received from about 150 individuals. The items have been compared with the catalogs of leading supply houses in order to determine the proper specifications for each item.

The lists are as follows:

1. Experiments for which equipment has been listed.
2. Apparatus for individual pupils.
3. Apparatus for individuals or small groups working successively.
4. Chemicals.
5. Stock apparatus.
6. Additional desirable apparatus.
7. Pertinent suggestions to the teacher.

Quantities, prices, brands, and precise specifications are stated. The substitution of one reagent for several, where the one will adequately suffice, is suggested, and a separate list of these substitutions is included.

The equipment lists contain all articles required for the experiments designated by the Senate of Chemical Education and the College Entrance Examination Board.

This fund of specific information is augmented by recommendations and advice which increase its usefulness to all chemistry teachers, and especially those in small high schools. It contains suggestions to both teacher and student, and for the storing of chemicals.

NO REPRINTS AVAILABLE—ORDER YOUR COPY NOW

JOURNAL OF CHEMICAL EDUCATION
20th & Northampton Streets
Easton, Pa.

Send me.....copies of your August 1937 issue at 50c each. $.....enclosed.

Enter my subscription for.....years starting with the August 1937 issue.

Name .....

Street .....

City .....State.....

School .....Position.....

SUBSCRIPTION RATES

1 Year for $3 2 Years for $5 3 Years for $7

Canadian Postage 50 cents a year extra; Foreign Postage $1 a year extra

PURPOSE

It is the hope of the Committee that this report will:

1. prevent foolish buying by inexperienced teachers;
2. aid schools to secure necessary equipment;
3. establish definite equipment requirements and specifications;
4. establish definite equipment standards;
5. eliminate dependence upon lists furnished by supply houses;
6. promote economical buying;
7. demonstrate to boards of education and other purchasing agents the desirability of good equipment;
8. reduce the number of unnecessary accidents in the laboratory.

HEINRICH WIELAND (1877–)

For biographical note contributed by Dr. Ralph E. Oesper, of the University of Cincinnati, see page 344. Dr. Oesper also lent the photograph here reproduced.

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

EDITOR'S OUTLOOK

THAT PESSIMIST'S HERE AGAIN. In the June *Journal of Higher Education* W. H. C. (Assistant Editor W. H. Cowley?) develops a thesis that seems to us to invite further discussion. Under the title "Morgan versus Hutchins" the editorial commentator referees what he conceives as a fundamental conflict in the educational philosophies of these well-known educators and, after getting in a few punches of his own in the clinches (as is the privilege of an editorial referee), leaves one with the impression that Mr. Morgan wins at least a moral victory.

Mr. Hutchins is quoted as saying: "If education is rightly understood, it will be understood as the cultivation of the intellect." It will probably be a matter of profound indifference to Mr. Hutchins if he ever finds it out, but that once he said something we thought we could both understand and endorse. It is characteristic of Mr. Hutchins' literary style that, whether his pronouncements call forth criticism or approval, they inevitably beget explanations and interpretations. Sometimes he disconcerts his opponents by disclaiming the argument they have set out to refute, and sometimes he confounds his self-appointed allies by repudiating the motion they have seconded.

W. H. C. reacts normally; he explains Mr. Hutchins' position further. "Stated briefly it amounts to this: the *only* function of higher education is the training of the mind. Everything else is extraneous. Colleges and universities have no responsibilities for students aside from the cultivation of their intellects. In a word, the philosophy of higher education must be unmistakenly and frankly intellectualistic." Perhaps Mr. Hutchins would not hold still for all this. After all, he is also quoted as saying, "This is not to disagree with the attitude that moral values, high ideals, and strong principles must be among the results of education."

Mr. Morgan's attitude is set forth in part through the following quotation. "Character in business and in government will solve seemingly inextricable complexities; make unnecessary and meaningless vast systems of checks and balances, of laws, regulations, surveillances, inspections, and prohibitions; eliminate need for constant exercise of shrewdness and suspicion; and release energies for constructive efforts. The limits of character mark the limits of good government and good business." It is inferred, without substantiating quotation, that since "intelligence is not enough," Mr. Morgan would have education supply the lack.

It may be that the *non sequitur* in this line of argument is not apparent to Mr. Morgan. To us it appears just as logical to say that, since typed correspondence is not enough, typewriters should be required to sew a fine seam, wash dishes, and darn socks. What has education ever done that it should be called upon to work miracles? Thus far it hasn't even learned to pull rabbits out of opera hats.

If in the next few millenia education can teach suckers not to run after confidence men, it will have done wonders. There is little enough hope of that, and still less of teaching confidence men to give suckers a break. One may exterminate wolves with shot, trap, and poison, and one may starve them out by depriving them of their natural prey; we venture to doubt that one can educate them to vegetarianism.

The PRODUCTION *of* ELECTROTYPES

C. E. RONNEBERG

Herzl City Junior College, Chicago, Illinois

INTRODUCTION

THE extent to which our modern civilization has become dependent upon the printing art for the dissemination of knowledge is indicated by the fact that printing is one of our major industries. We depend upon the radio, the telephone, and the telegraph to transmit information rapidly throughout the country, but to impart this information to the average individual, we must depend upon newspapers, magazines, circulars, books, etc. In 1933 the printing industry ranked second among the industries in this country in number of establishments, fifth in the amount of wages paid employees, and eighth in the number of wage earners employed.[1] The Pennsylvania Gazette, published by Benjamin Franklin, was printed with a hand press, and the circulation probably did not exceed a few thousand copies. The great advance in the printing industry since that time can be illustrated by the data referring to the publication of a single edition of the general catalog of a Chicago mail order house. Into its production went 12,122 tons of paper, equivalent to the load of a 130-car freight train, and enough printer's ink to fill two standard swimming tanks sixty feet in length. One hundred thousand people had a hand in the planning, creation, and distribution of this single edition of over 6,000,000 copies.[2]

FIGURE 1.—POURING WAX FOR A MOLD

John Gutenberg printed with his hand press from the original type after it had been set and locked in a suitable form, and this practice continued well into the nineteenth century. This method was entirely satisfactory as long as a single edition of a newspaper or book would number only in the hundreds or a few thousands. But, with the development of our large metropolitan centers, and the development of a large reading public, the practice of printing from the original type became impractical and costly. Again, necessity was the mother of invention, and during the nineteenth century there were perfected various methods of reproducing the original type in metal, which permitted printing from these reproductions.

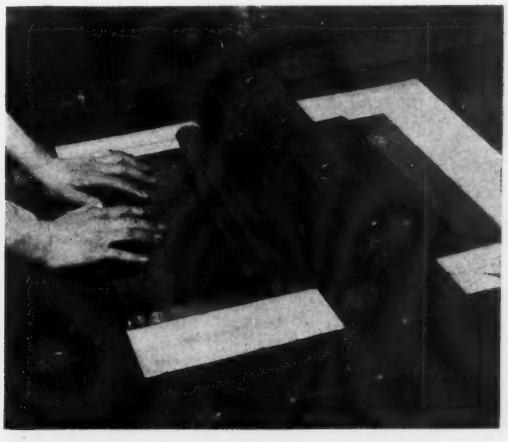


FIGURE 2.—SHAVING A WAX MOLD TO PROPER THICKNESS

The stereotype process and the electrotype process were the first reproduction methods to be developed. The stereotype process is essentially a method for reproducing a type form by making an impression of the type in a paper mold and then casting it with type metal. It was the stereotype process, along with the linotype, which made possible the rapid and cheap production of the modern newspaper. From one point of view, an

[1] Data supplied by United Typothetae of America, Washington, D. C., from the statistics of the U. S. Bureau of Census for 1933.

[2] The fall and winter catalog for 1936–1937 of Sears, Roebuck and Company.

electrotype is also a casting made in a mold, not by hot pouring of a metal, but by electrolytic deposition of a metal, usually copper, or nickel. The stereotype process is largely a mechanical process, while the electrotyping

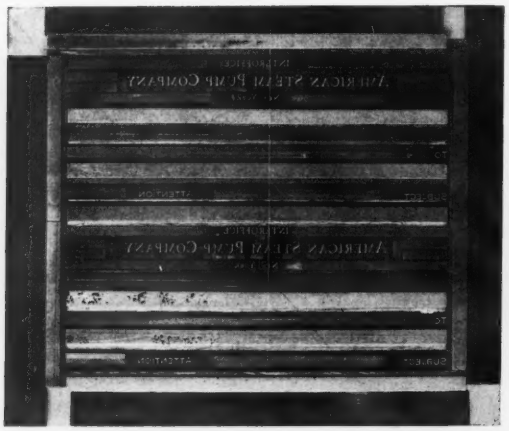


FIGURE 3.—A TYPE FORM READY FOR THE MOLDING PRESS

process is, to an important extent, an electrochemical process, and constitutes one of the most important applications of electrochemistry. Both the stereotype and electrotype processes make reproductions of a type form, or engraving, which in itself could be used in the printing process. During the present century there have been developed processes which produce a print-

FIGURE 4.—A MOLDING PRESS

ing surface by photographing on metal the material which is to be printed. The whole series of operations for making the printing surface is entirely photographic. The rotogravure process, so much used for the illustrated supplements of the Sunday newspapers, is the best-known example of this development in the art of printing. While the rotogravure process has displaced the electrotype process for certain types of printing, practically all printing, exclusive of newspapers, is still done from electrotypes. It is also true that all really high-class printing, where the utmost of detail and faith-

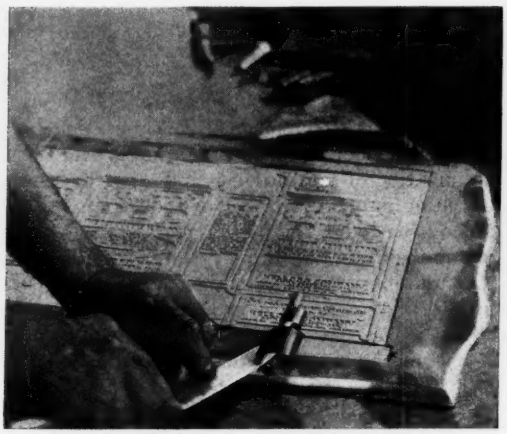


FIGURE 5.—TRIMMING A WAX MOLD

fulness of reproduction is necessary, is still done with electrotypes, except when the number of impressions is comparatively small.

An electrotype is a duplicate in copper, or nickel, of a printing surface, made by depositing the metal electrolytically in a reverse mold of the original print-

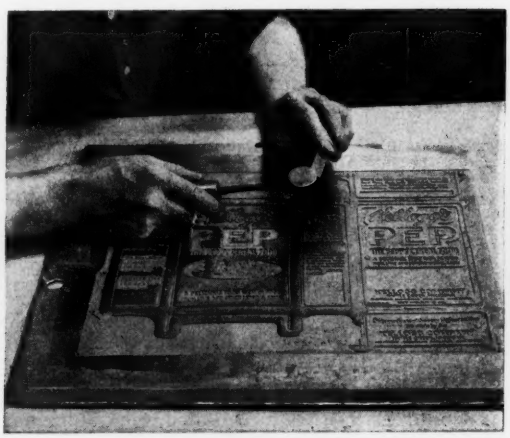


FIGURE 6.—"BUILDING" THE PROPER RELIEF ON A WAX MOLD

ing surface. The original material can be anything that can be used as a printing surface, such as ordinary type, a delicate etching, or a photo-engraving. Electrotypes

are necessary in the printing industry for a number of reasons:

1. To prevent wear on type in order to retain its sharpness of detail. Type metal is a soft alloy of tin, lead, and copper. If used on a press, only about 50,000 to 75,000 impressions can be made before loss of sharpness

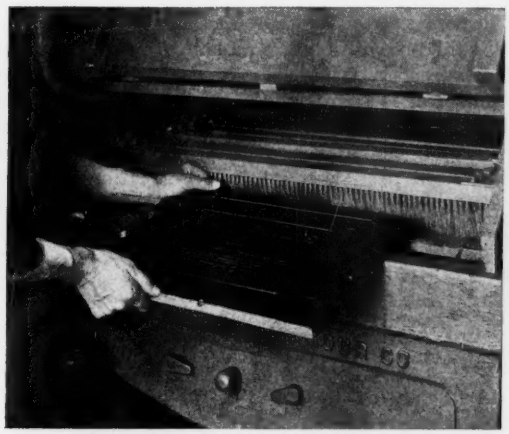


FIGURE 7.—GRAPHITING A WAX MOLD

becomes noticeable. If more than this number of sharp impressions are needed, the printer must set up the whole printing surface again, using new type. This, of course, is an expensive process. It is much cheaper to

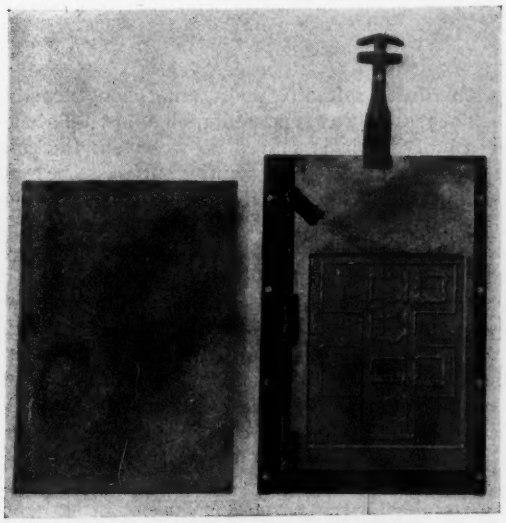


FIGURE 8.—MOLD IN SHEET LEAD

prepare an electrotype from which as many as 300,000 to 500,000 (for copper), or 400,000 to 800,000 (for nickel) impressions can be made without loss of detail.

2. To preserve costly original engravings, halftones, and color-process plates. The original cost of these printing surfaces is relatively great, and it is not necessary to

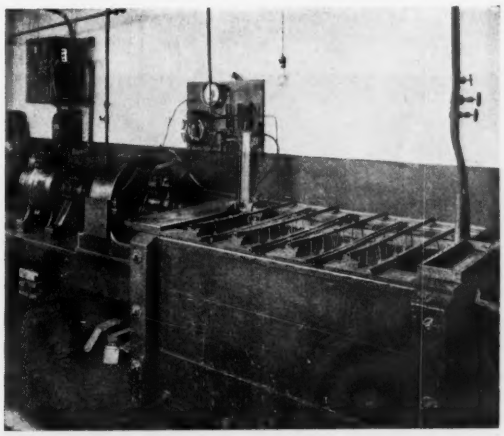


FIGURE 9.—SMALL ELECTROTYPING TANK WITH MOTOR-GENERATOR AND CONTROL BOARD

ruin them by printing from them. Instead, the actual printing can be done from electrotypes. For example, the master engravings for our paper money are prepared with the utmost care by skilled engravers. To attempt to supply all the paper money used in this country from

FIGURE 10.—REMOVING A SHELL FROM ELECTROTYPING TANK FOR INSPECTION

hand-made engravings would increase the cost many fold. Instead of this method, our paper money is actually printed from electrotypes of the original master engravings. It would require an expert in the printing industry to detect the difference between a piece of paper

money printed from the original engraving and from an electrotype of that engraving.

3. To reduce the cost of printing. To produce in type metal all the printing surfaces necessary to print an edition of a large catalog, for example, would be prohibitive. The type would have to be reset and the half-

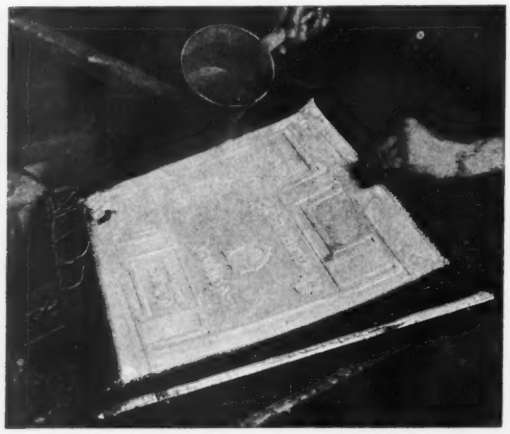


FIGURE 11.—STRIPPING A SHELL FROM A WAX MOLD

tones renewed many times. The expense of preparing the first printing surface has to be incurred only once, since as many electrotypes of this surface can be prepared at a relatively low cost as may be necessary.

FIGURE 12.—COVERING THE BACK OF A SHELL WITH TIN FOIL

4. Electrotypes are absolutely necessary for printing on high-speed rotary presses. It is impossible to lock ordinary type or linotype slugs on the cylinder of a rotary press so that they would stay in place. Instead, an electrotype is prepared, and then bent into the circular shape necessary to fit the printing cylinder. The electrotype can be firmly locked into place.

5. Finally, electrotypes are necessary to print with corrosive colored inks. These corrosive inks soon attack ordinary type metal, but have no noticeable effect on a nickel electrotype.

THE PRODUCTION OF AN ELECTROTYPE

The first step in the reproduction of a printing surface is the preparation of a mold. For ordinary work, which consists of type and coarse engravings, the molding material is a specially compounded wax, usually made from ozokerite to which certain substances such as beeswax, gum turpentine, pitch, etc., are added to give certain necessary physical properties, such as a

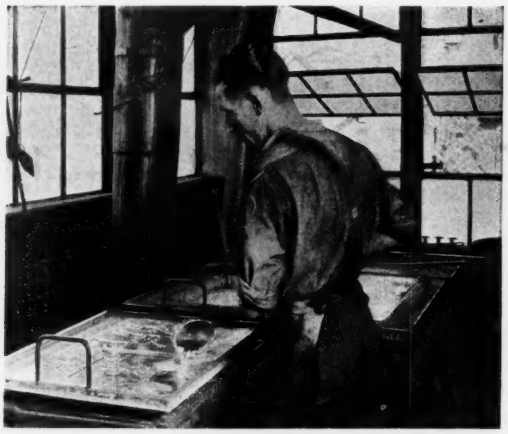


FIGURE 13.—"BACKING-UP" A SHELL WITH TYPE METAL

proper hardness, softening point, amorphous structure, etc. The molten wax is poured upon a metal plate and after solidifying it is shaved to a certain thickness. (See Figures 1 and 2.) The printing surface to be reproduced must be in a form suitable for printing. (See Figure 3.) The impression of the type form in the wax mold is made in an hydraulic press. (See Figure 4.) In order to get a sharp impression in the wax, it is necessary to use very great pressures, and under these conditions the wax flows so that the mold has many surface irregularities. These are removed by trimming with a warm steel knife (Figure 5), and the mold is then built up to a suitable degree of relief. The reader must bear in mind that the impression of the face of the type is in the bottom of the indentations. This building-up process is accomplished by melting wax into place with a warm iron of a shape suitable for this purpose (Figure 6).

The molding wax, of course, is not a conductor. The surface of the mold is made a conductor by brushing into the wax a layer of very fine graphite, especially prepared for this purpose. The graphite can be brushed into place as a dry powder or in suspension in water. It is customary to carry out this brushing process me-

chanically. Figure 7 shows a workman placing a wax mold in a graphiting machine.

The time required to obtain a firm layer of copper from the electrolytic bath over the whole face of the mold is greatly reduced by supplementing the conducting layer of graphite with a thin layer of copper. This is accomplished by sprinkling the face of the mold with fine iron powder followed by a concentrated solution of copper sulfate. Copper is deposited by replacement,

$$Fe^\circ + CuSO_4 \longrightarrow FeSO_4 + Cu^\circ$$

Without this preliminary treatment the copper deposit must grow out from the place of electrical contact at the top of the mold. The wax mold is now ready for the copper plating bath.

For the reproduction of very fine halftones and the plates used for printing in color, the molding material

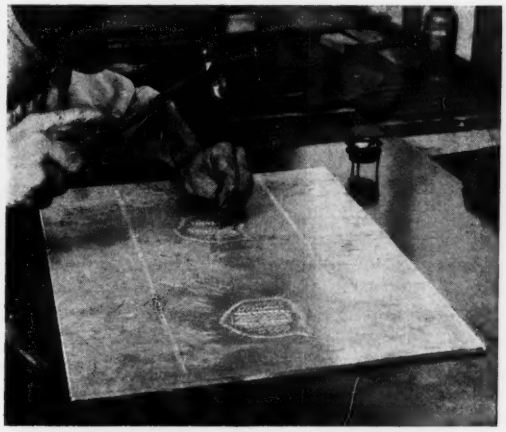


FIGURE 14.—A "FINISHER" AT WORK

is sheet lead. Actually, molding in lead is a simpler process than wax molding, since the lead itself is a conductor. Figure 8 shows a sheet of lead before and after molding. The molded sheet is held in a special support for immersion in a metal plating bath. In order to prevent the deposited metal from sticking to the metal mold, it is treated with a dilute solution of sodium sulfide or sodium chromate. The thin layer of lead sulfide or chromate which is formed serves to prevent a metal-to-metal bond.

The molds as prepared above are now placed in the metal plating bath and allowed to remain until the required thickness of metal is deposited. The principles involved in this operation will be discussed later. About two hours is required to produce the requisite thickness for a copper shell (0.15 to 0.25 mm.). Figure 9 shows a typical, small installation of an electrotyping tank with the necessary motor-generator set and control board.

Nickel is a more expensive metal than copper and also slower and more difficult to deposit. For this reason, it is customary to leave a mold in a nickel-plating bath only long enough to form a deposit about 0.02 mm. in thickness. The mold is then removed and placed in a copper plating bath and enough copper deposited on the back of the nickel to give the shell the necessary mechanical strength.

The deposited shell of metal is stripped from the wax mold by the use of hot water (Figure 11), and it is then ready for a "backing" of type metal. It is necessary that the metal form a firm bond with all parts of the

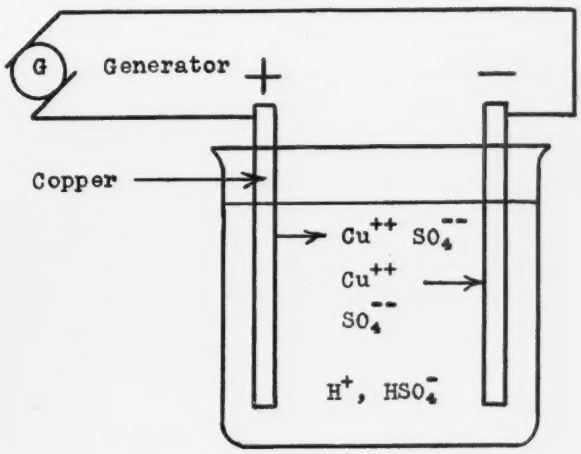


FIGURE 15

copper shell. To accomplish this, the shell is placed face downward on a heated iron pan especially designed for the purpose and covered with pure tin foil, after a preliminary treatment with a solution of zinc chloride in hydrochloric acid to act as a flux. The molten type metal is then poured on top of the layer of tin foil. Photographs of these operations are shown in Figures 12 and 13.

The final operations in preparing an electrotype are largely mechanical operations necessary to get the electrotype ready for the printer. The finisher must remove any slight irregularities from the printing surface. Thus, in Figure 14, the workman is pounding the back of a plate to eliminate some "valleys" in the face so that the printing surface will be a plane.

THE DEPOSITION OF COPPER

The outline of the electrotyping process thus far given indicates that the production of an electrotype involves a long series of operations that are mechanical in nature. The actual deposition of the metal, however, is distinctly an electrochemical process. The solution used in the electrotyping tank, which consists principally of copper sulfate and sulfuric acid, is one of the simplest solutions used in electroplating. The essential elec-

trode reactions are quite simple (Figure 15). The graphited mold, of course, constitutes a cathode.

At anode: $Cu^{\circ} \longrightarrow Cu^{++} + 2e$
At cathode: $Cu^{++} + 2e \longrightarrow Cu^{\circ}$
Net change: Cu° (from anode) $\longrightarrow$ Cu° (on cathode—the electrotype)

There is nothing critical about the composition of the solution. A common range of concentrations will be from 60 to 80 g./l. of sulfuric acid and 240 to 270 g./l. of copper sulfate. The latter is supplied in the form of commercial blue vitriol. The function of copper

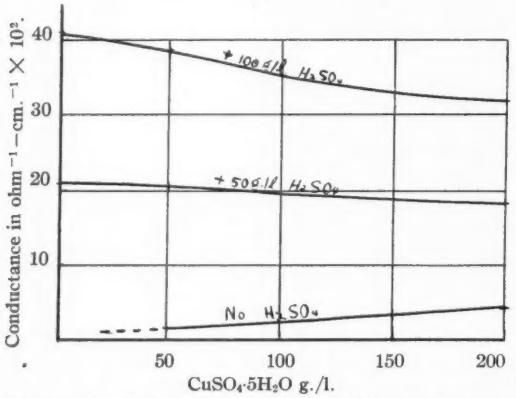


FIGURE 16.—CONDUCTANCE OF COPPER SULFATE-SULFURIC ACID SOLUTIONS AT 25°C.[3]

sulfate is obvious. The function of the sulfuric acid is not so obvious; it actually has a number of very important functions. The most important function of the sulfuric acid is to increase the electrical conductivity of the solution, due to the great mobility of the hydrogen ions. The relative conductivity of solutions of copper sulfate with and without sulfuric acid is shown in Figure 16.

The relatively great effect of sulfuric acid on the conductance of solutions of copper sulfate is clearly indicated. Industry, of course, must pay attention to costs of production. Hence the electrotyper always strives to reduce the power consumption in his electrotyping tanks (Power = IE). This is a question of making the voltage drop (E = RI) across the tanks as small as possible, and one important factor in the determination of this voltage drop is the over-all resistance of the tank, which, as we have seen, is markedly affected by a small quantity of sulfuric acid.

The anodes are large slabs of commercial copper, either cast or rolled, and cut into the proper shape (Figure 16). The anode, as well as the mold, is supported by a special hook on copper rods which are placed across the type of the tank. They are well insulated from the tank and solution with porcelain or glass. The rods are alternately made positive and negative and are placed comparatively close together so as to reduce the overall resistance of the tank. (Refer to Figures 9 and 10.)

The electrotyper has found by experience and by experiment that the physical properties of the finished shell are profoundly affected by certain operating conditions. For example, the tensile strength and the hardness of the shell depend to a large degree upon the size of the individual copper crystals. Thus, in general, the tensile strength and hardness increase with the decrease in crystal size. The crystal size is closely dependent upon the rate at which copper is transferred from the form of ions in the solution to the characteristic crystal lattice of copper in the solid metal. This rate depends upon a number of different factors: (1) the current density; (2) the temperature; and (3) the concentration of cupric ions, Cu^{++}. The successful operation of an electrotyping tank depends upon a series of compromises of procedure because of the many variables entering into the whole operation. Furthermore, the familiar procedures for electrolysis obtained under ideal experimental conditions with solutions that are very dilute are often but poor guides to the successful operations of an electrotyping tank. The operator must watch the rate that copper ions are being discharged at the cathode by watching the character of the deposit itself. Hence the operator will remove a case from time to time to note the character of the deposit. (Refer to Figure 10.)

The most important single factor in controlling the character of the deposit is the current density. By this term is simply meant the number of amperes per square foot or square decimeter of cathode surface. The essential reaction at the cathode we have given before,

$$Cu^{++} + 2e \longrightarrow Cu^{\circ}$$

The current, of course, supplies the electrons for this reaction. If the electrons are supplied relatively slowly, which means low current density, there is a tendency to develop large copper crystals, which is objectionable. On the other hand, if the current density is made too large, the solution in the immediate vicinity of the cathode will change in the relative concentrations of copper and hydrogen ions. As the copper ions are removed by deposition they will be replaced by hydrogen ions in relatively greater numbers than copper ions, since the migration velocity of the hydrogen ion is so much greater (7 to 1) than that of the cupric ion. Eventually, the concentration of hydrogen ions around the cathode becomes so great that the following reaction occurs rapidly enough to form gaseous hydrogen,

$$2H^{+} + 2e \longrightarrow 2H^{\circ} \longrightarrow H_2 \text{ (gaseous)}$$

The copper will no longer be deposited as a firm, adherent metallic layer. In the language of the tank man, the deposit is said to be "burnt".

[3] RICHARDSON AND TAYLOR, *Trans. Am. Electrochem. Soc.*, **20**, 179 (1911).

The tank operator, then, must so regulate the voltage applied on the tank as to have a current density great enough to give a shell of sufficient hardness and in as short a time as possible, and yet avoid the evolution of hydrogen gas. In practice, current densities will vary from 50 to 150 amperes per square foot.

High temperatures also tend to promote large crystal growth. The current passing through a large tank may be as high as 2000 amperes, so that the heating effect is often appreciable ($H \propto RI^2$). High temperatures must also be avoided because of the softening effect on the wax molds. It is customary to operate tanks at about 25°C., using cooling coils in the tanks if necessary to maintain this temperature.

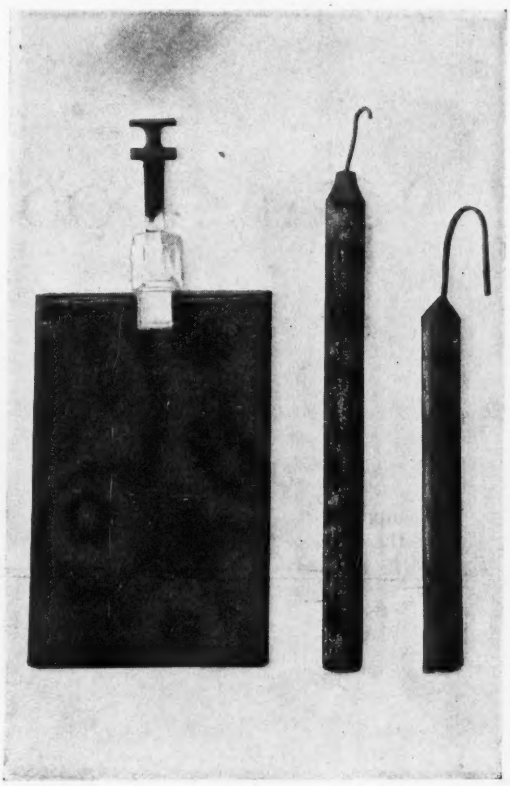


FIGURE 17.—COPPER ANODE (LEFT) AND NICKEL ANODES (RIGHT)

The third important way to control the size of the copper crystals is to control the concentration of cupric ions. It has been known for a long time that a high concentration of metal ions about a cathode favors the formation of large crystals and a loose, non-adherent deposit. Thus it is practically impossible to obtain an adherent deposit of silver by electrolysis of a solution of silver nitrate, which is highly ionized. Silver must be deposited from a solution such as potassium silver cyanide, $KAg(CN)_2$, which will contain a relatively high concentration of the complex silver-cyanide ion, $Ag(CN)_2^-$, but a low concentration of silver ions, Ag^+, about the cathode because of the small dissociation of the cyanide complex. This favors the formation of a larger number and thus necessarily smaller crystals, since at any given time any particular crystal on the cathode will not be surrounded by many ions in the solution.

The effect of cyanide in a silver bath in controlling the actual concentration of silver ions is understood, but the effect of sulfuric acid in reducing the concentration of cupric ions in a solution of copper sulfate is not so well understood.

The adherents of the older theories of ionization believe that the function of the sulfuric acid is to reduce the ionization of the copper sulfate by the common ion effect. There is also the possibility of the formation of lowly ionized complex ions of the type, $Cu(SO_4)_2^=$. Apparently, very little work has been done to prove the existence of compounds of this type. It is true, however, that the existence of complex ions of copper chloride with hydrochloric acid, such as $HCuCl_3$, is well known. Still another possibility is the formation of the ionic complexes of the type postulated in the theory of Debye-Hückel. Thus, there might be complexes of the cupric ion surrounded by an atmosphere of sulfate ions.

Examination of the equations for the reactions occurring at the anode and at the cathode (page 308) indicate that there should be no change in the composition of the solution with continued operation of the tank. However, the usual experience is that there is a slow, steady decrease in the concentration of the sulfuric acid and a steady increase in the concentration of the copper sulfate. The explanation for this change lies in the fact that the anode efficiency is always greater than one hundred per cent. The cathode efficiency is usually very close to the theoretical limit of one hundred per cent. An anode efficiency of over one hundred per cent. may seem a little unusual, but the explanation is found in the simultaneous operation of two undesirable reactions which cannot be avoided. In order to keep a supply of copper ions in the vicinity of the cathodes, it is necessary to agitate the solution. This agitation is usually done with streams of compressed air issuing from perforated pipes in the bottom of the tank. In the presence of air there is a steady production of copper sulfate as indicated in the following equation

$$2Cu + 2H_2SO_4 + O_2 \longrightarrow 2CuSO_4 + 2H_2O$$

A second reaction to account for the steady increase in the content of copper sulfate lies in the fact that copper forms two ions, the cuprous, Cu^+, and the cupric, Cu^{++}. There is evidence to indicate that some of the copper dissolves in the cuprous state

$$Cu^\circ \longrightarrow Cu^+ + e$$

to form cuprous sulfate. This means that two moles of copper will be dissolved at the anode for each two faradays

of electricity when it dissolves in the cupric state. The cuprous sulfate is soon converted to cupric sulfate as a result of reacting with air in the presence of sulfuric acid

$$Cu_2SO_4 + H_2SO_4 + 1/2\ O_2 \longrightarrow 2CuSO_4 + H_2O$$

The above reactions account, therefore, for the steady decrease in the amount of sulfuric acid present and the increase in the amount of copper sulfate. The operator of copper electrotyping tanks must, therefore, analyze the solutions in the tanks from time to time and then adjust the composition of the solutions. This usually means removing some of the solution, replacing the part removed with water, and adding enough concentrated sulfuric acid to restore the proper concentration of acid. Enough solution must be removed so that the content of copper sulfate will be the desired amount after the addition of an equivalent volume of water.

The halftones illustrating the various operations involved in the preparation of an electrotype were donated by The Chicago Employing Electrotypers Association, 431 South Dearborn Street, Chicago, Illinois.

An article to be published later will discuss the production of nickel electrotypes.

An IMPROVED CHEMICAL HOOD

EUGENE C. BINGHAM

Lafayette College, Easton, Pennsylvania

CHEMISTS are not expected to work under a hood except when their work makes the use of a hood necessary. This fact seems to prove that the problem of the chemical hood is still far from solved. It will be solved when chemists find it as agreeable to work under a hood as elsewhere. It is thus necessary to provide duplicate working space for each chemist, which greatly adds to the cost of laboratories. In order to save expense the number of hoods is reduced, but the discomfort of those working at the hoods is thereby increased.

A study of the problem suggests several reasons for the chemist's dislike for the hood. The space may be cramped, the draught defective, the lighting may be poor, the windows may stick, the hood may be distant from one's other work, there may be lack of privacy for one's work, and there may even exist a lack of tidiness where several share the same working space. None of these reasons serves to explain the curse of the chemical hood, for all of these objections can be overcome, and yet the curse upon the chemical hood still remains. The real objection is connected with the posts between the various windows. They are often quite wide to contain the boxes in which run up and down the counterweights for the windows. If one considers that a chemist cannot be expected to be in physical contact with the posts, a considerable fraction of the working space is given over to the posts. On further consideration, one will observe that no useful purpose is achieved by having the counterweights occupy the most valuable space at the front of the hood. They could equally well be carried to the rear of the hood or to any convenient point.

However, no matter how much the posts are reduced, so long as the posts remain the objection to the hood will remain. The reason for this is clear, for no one

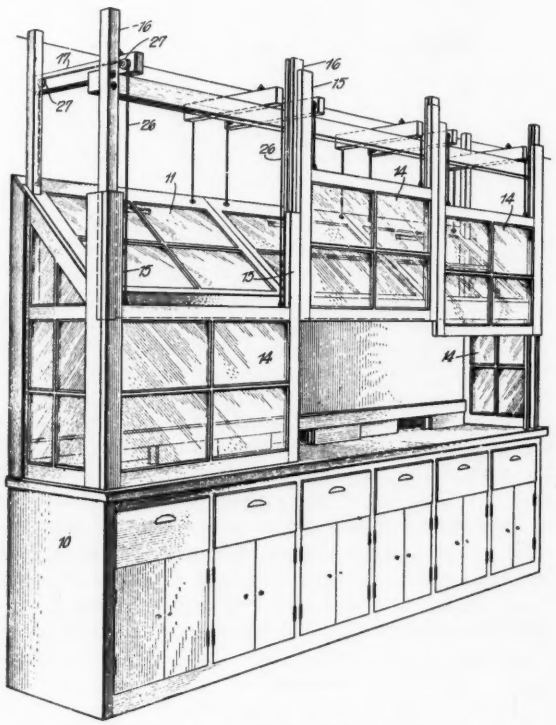


FIGURE 1.—A PERSPECTIVE VIEW OF HOOD

works in front of a post, regardless of its size. If a chemist requires a certain space before a hood s, and the width of the window is w, the number who can work

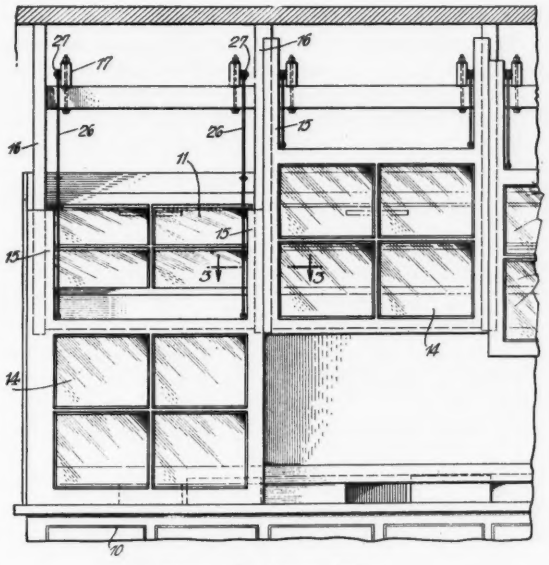


FIGURE 2.—FRONT VIEW

at a given window is s/w, but only integral values count. Thus the fractions are all to be disregarded. Going from mathematics to ordinary language, by his arrangement of the posts the designer of the laboratory determines how many may work at the hoods without crowding. The designer may not have had any adequate

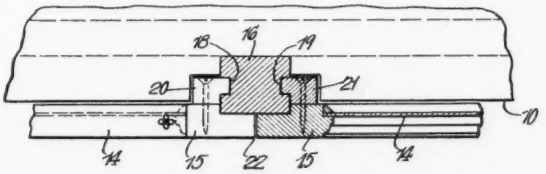


FIGURE 3.—HORIZONTAL SECTION ON LINE 3-3 OF FIGURE 2

conception of the nature of the problem, and thus a very large part of the available hood space is rendered unavailable.

The question then arises as to whether it is not possible to do away with the posts altogether. As a matter of fact, hoods can be supported from the walls or ceiling. A false back of transite board can be used to afford space for the movement of noxious gases to the flue and also for the rise and fall of counterweights. Since the fumes are at most very dilute, no trouble need be encountered from the rusting of metal.

One difficulty in doing away with the posts is that the windows when pulled down would run out of their guides and be subject to objectionable lateral motion. This difficulty is, however, easily and completely overcome in the following manner.

An experimental hood was built to try out the idea, but not necessarily of the construction or material most

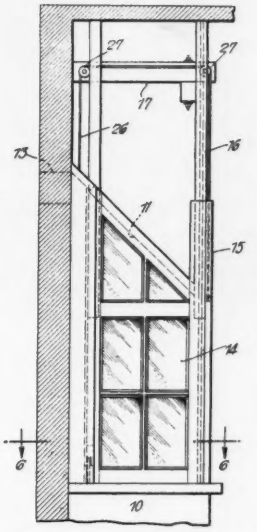


FIGURE 4.—END ELEVATION

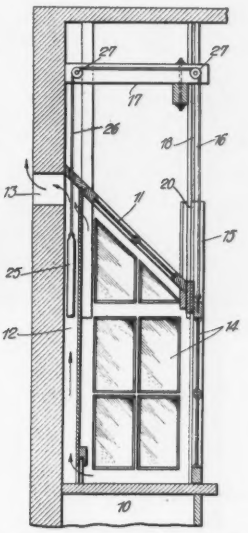


FIGURE 5.—END VERTICAL SECTION

suited for later use, shown in perspective in Figure 1, and in front view in Figure 2.

The posts (16) are cut off at a convenient height, some six feet or more above the floor. The windows (14) are retained because they are needed at times to prevent cross-currents when very noxious gases are in use, but the sashes (15) are extended upward above the

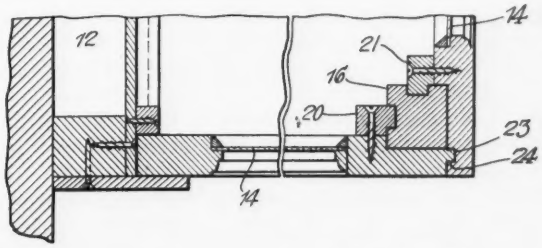


FIGURE 6.—SECTION ON LINE 6-6 OF FIGURE 4

normal height of the windows, so that the windows can be pulled down all of the way without the sashes losing effective contact with the guides. In order that the windows may fit each other snugly even below the post it is necessary to place the posts in a plane somewhat behind the plane of the windows. A simple tongue-and-groove construction is employed, shown in Figure 3 for

a section on the line 3-3 of Figure 2. The wood of the tongues and of the posts was maple, and the surfaces were smoothed and fitted carefully. The grooves

FIGURE 7.—THE HOOD IN USE

were greased originally, but they have not required a second treatment in two years.

The construction permits the ends of the hood to be raised and lowered, as well as the front, as shown in Figure 6.

In the end views, Figures 4 and 5, the space behind the hood is well shown, with the upper and lower openings. The space is kept as free as possible to keep the ventilation unimpeded. Small blocks only are used to attach the transite board to the wall. The counterweights are conveniently placed in this space as shown in Figure 5, or springs may be used as indicated in Figures 1 and 2.

This system does not require the strong fans necessary for individual hoods, because when noxious gases are once in the space behind the "false" partition they need not move rapidly, since there is little resistance, no sharp bends, and no possibility of cross currents.

Electric lights placed high within the hoods have been found very helpful, but they are not indicated in the figures.

If it becomes possible to work agreeably under hoods the question arises, "Why not save the duplication of space, combining desks and hoods?" This we have done with entire success at the walls. The next question is, "Why not do away entirely with the wall hoods and use the desks in the middle of the laboratory, covered with the type of hood here illustrated?" We suggest that in this case a "false" ceiling must be used in place of the "false" wall.

Efforts are now being made to interest manufacturers who will supply this type of hood in wood or metal to those desiring it. It need not cost more than the forms of hoods now in use. In use it has been found thoroughly satisfactory in both an industrial and a college laboratory.

PHENYLARSONIC ACID AS A QUALITATIVE TEST FOR TIN

R. H. BULLARD

Hobart College, Geneva, New York

IN THE separation and qualitative detection of tin, one of the commonly employed methods is to separate it as Group IIB along with arsenic, mercury, and antimony by use of sodium or ammonium sulfide reagent. These metal sulfides are then reprecipitated with acid, filtered, and partially dried. The antimony and tin sulfides are dissolved out with 12 *N* hydrochloric acid. The antimony is separated and the tin tested for in the remaining solution.

We have noticed that students experience difficulty in detecting tin by this procedure. As a matter of fact, more errors are made at this point than at any other place in the entire analysis. A more certain test for tin seemed desirable, especially if it could be adapted to the conventional scheme of analysis.

Knapper, Craig, and Chandlee[1] state that tin is precipitated quantitatively by adding to a hot acid solution of the metal a saturated solution of phenylarsonic acid. To apply this quantitative precipitation to the conventional qualitative procedure the following method is used.

The Group IIB sulfides are heated with 12 *N* hydrochloric acid as usual. The antimony and tin sulfides dissolve and the filtrate containing these metals is diluted with water according to the customary procedure. Five cubic centimeters of this solution are taken and heated to boiling. To this hot solution are added ten cubic centimeters of a solution of phenylarsonic acid,[2] containing forty grams of phenylarsonic acid per liter of water, which has also been heated to boiling. A cloudy white precipitate of metastannic acid appearing almost at once is the test for tin. If the solutions are cold, antimony oxychloride will of course precipitate, but in hot acid the antimony remains in solution.

We have used this test in our classes for the last two years and, as a result, the errors in reporting tin have almost entirely disappeared.

[1] KNAPPER, CRAIG, AND CHANDLEE, *J. Am. Chem. Soc.*, **55**, 3945 (1933).

[2] Phenylarsonic acid may be obtained from the Eastman Kodak Company or it may be prepared according to directions in "Organic Syntheses," Vol. 15, p. 59.

The EPIGRAMS *of* REMIGIUS FRESENIUS I

RALPH E. OESPER

University of Cincinnati, Cincinnati, Ohio

REMIGIUS FRESENIUS, the founder and greatest of that remarkable line of chemists that now, in the fourth generation, is carrying on the family laboratory at Wiesbaden, was born at Frankfurt a. M. in 1818. His first scientific training came as a four-year apprenticeship in pharmacy, and during this time he attended lectures on chemistry, physics, and botany. Fascinated even during these youthful years (1836–40) by the allurements of chemical analysis, he spent his holidays and free time practising this art in the little laboratory he had fitted up in the summer house of his grandfather's garden. In 1840 he enrolled at Bonn, and during his second semester there he tried his wings for the first time and wrote an "Anleitung zur qualitativen chemischen Analyse." He had done this only to gain practice, but his professor insisted that this modest introduction to qualitative analysis be printed in order to give others its valuable contents. Little did the author dream how far this little candle would eventually throw its beam; numerous revisions and translations of it and its companion work on quantitative analysis (first edition 1846) have made "Fresenius" an honored name wherever chemistry is taught and practiced.

KARL REMIGIUS FRESENIUS

THE GALLERY

In those days there was only one place for a young man who had resolved to make chemistry his lifework, and the next four years were spent at Giessen. Successively student, private assistant, teaching assistant, privat dozent, Fresenius was thoroughly steeped in the spirit of the Liebig school, and this close association with that great educator and scientist left a permanent mark on the young man.

In 1845, Fresenius, who had already begun to make a name for himself by his excellent experimental studies, was called to Wiesbaden as Professor of Chemistry, Physics and Technology in the Agricultural Institut of Nassau. Here he found no laboratory, either for his own work or for instructional purposes, and this situation, intolerable to a vigorous chemist, fresh from Giessen, was soon remedied in his characteristically independent fashion. He decided to start a chemistry school of his own, and in 1847 bought a house, made of it both a home and a laboratory, and the first semester opened with an enrollment of five. This was the beginning of the school and laboratory whose service to

industry and to young people has ever since continued with constant growth.

The house, changed and enlarged as demanded by the expansion of the family, which finally contained

THE GALLERY FROM THE INSIDE

seven children, was a home in the fullest sense. Here the beloved father and grandfather lived out the rest of his days, shedding his good humor and wise counsel over all who came under his roof.

This expert chemist, author of texts of world renown, founder of a noted school, successful teacher, founder and editor of the *Zeitschrift für analytische Chemie*, progenitor of a long line of eminent chemists, honored by his professional colleagues and by those high in government affairs, withal remained a man of simple tastes and habits. When he sought recreation from the exhausting mental toil of his multifold activities, he sought the open spaces. He loved to walk through the beautiful country around Wiesbaden, and this form of exercise became a daily necessity. Consequently, to prevent inclement weather from interfering with his constitutional, he built along one side of his house a covered gallery, and here took his walks when the outside conditions were bad.

To those who have lived as much as he come certain philosophies of life, and these distillations from his active mind were crystallized into simple verses and set down on the wall of his promenade for all to read and digest.

To translate these would probably rob them of their bloom and flavor. They are given here as they still shine forth on the walls of his home from whence, in 1897, this wise old man was called to his reward.

Ein Rath, der im Leben Segen schafft:
Vertraue Gott und der eigenen Kraft.

Freundliche und gute Worte
Finden allzeit offne Pforte.

Musst Du Dich in der Jugend müh'n,
So wolle nicht darüber klagen,
Nur Bäume, die im Lenze blühn,
Können im Herbste Früchte tragen.

Nach goldner Frucht vom Baum des Lebens
Greift der Müssiggang vergebens.

Streben liebe ich im Leben,
Was zu niedrig, sollst Du heben;
Stetes Aendern muss ich hassen,
Gutes soll' man gut belassen.

Tadelst Du, thu's mit Bedacht;
Höher steht, wer's besser macht.

Forsche gründlich,
Rede wahr,
Schreibe bündig,
Lehre klar.

Lass Dir in's Ohr ein Wörtlein raunen:
Beherrsche Stimmungen und Launen.

Willst Du im Leben Grosses erreichen,
Darfst Du Dich niemals kleinlich zeigen.

Wünschest Du ein froh Geschick,
Nütze auch den Augenblick.

Geht es Dir im Leben gut,
Wahre Dich vor Uebermuth,
Gehen schlechter die Geschäfte,
So verdopple Deine Kräfte.

Trittst Du frisch an's Werk heran,
Ist die Arbeit halb getan.

Zweifelst Du, was Recht und Pflicht,
Thu' was Dein Gewissen spricht.

Glauben was man hofft,
Führt zu Täuschung oft.

Kannst Du, ich hab' mein' Pflicht gethan,
Getrosten Muthes sagen,
Dann lernst Du auf der Lebensbahn
Auch schwere Lasten tragen

Freundschaft treu, fest und rein,
Im Lebensring der Edelstein.

Legst Du Abends Dich zur Ruh',
Mazh' das Sorgenkästchen zu.
Drückst Du noch so fest darauf,
Morgens springt von selbst es auf.

Bei vollem Ernste, froher Sinn
Dem Leben köstlicher Gewinn.

Willst Du mit weissen Haaren
Das Leben noch geniessen,
Lass Dich in jungen Jahren
Die Arbeit nicht verdriessen.

Soll das Leben Dir gelingen,
Halte Mass in allen Dingen.

Das Ganze ist in guter Hut,
Wenn jedes Glied das seine tut.

Wer froh durch's Leben will wallen,
Dem muss es im Hause gefallen.

DEMONSTRATION OF A NEGATIVE TEMPERATURE COEFFICIENT OF SOLUBILITY

L. A. BATEMAN* AND W. C. FERNELIUS

The Ohio State University, Columbus, Ohio

IN DISCUSSING the effect of temperature upon the solubility of solids in liquids, the authors of general chemistry textbooks invariably point out the increasing solubility in water of the vast majority of the common inorganic compounds with rise in temperature. The practically unchanging solubility of sodium chloride and the inversion of the solubility (transition point) of sodium sulfate are also discussed. Many (but not all) such authors point out that a few inorganic substances such as calcium hydroxide and calcium sulfate (a few authors also mention calcium chromate) actually become less soluble in water with rising temperature.

In attempting to demonstrate this exceptional behavior before large freshman classes by warming a saturated solution of lime water contained in an open beaker, we have always been disappointed in that the experiment was unconvincing, because (1) the quantity of solid precipitating is very small; (2) one is never certain that the minute quantity of precipitate has not formed as a consequence of the evaporation of some of the solute. Calcium sulfate and especially calcium chromate would seem to be superior to calcium hydroxide in such a demonstration, yet when their saturated solutions are heated (both in an open beaker and in a sealed tube) no precipitation is observed. A saturated solution of lithium carbonate on warming forms a precipitate which, however, redissolves only with extreme difficulty.

What the demonstrator needs is a substance which is moderately soluble at room temperature but becomes practically insoluble at 100°. Then the experiment should be conducted in such a fashion that there is practically no evaporation of the solvent. These requirements may be easily met by the use of solutions of cerous sulfate,[1] $Ce_2(SO_4)_3$ (see Table 1), contained in sealed tubes (see Figure 1). Fifty cc. of a saturated (room temperature) solution of cerous sulfate contained in a sealed tube one inch in diameter will begin to deposit needle-like crystals at 84°. When the temperature has reached 100° the mass of crystals will occupy approximately $^3/_4$ of an inch in the end of the tube. By immersing the tube in cold water and shaking, these crystals are brought back into solution.

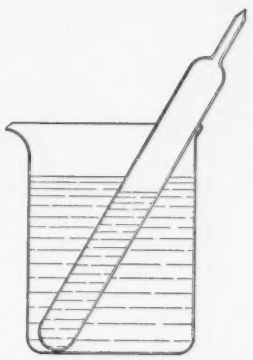


FIGURE 1

One other system which seems to offer possibilities is a saturated solution of lithium ethoxide, $LiOC_2H_5$, in ethyl alcohol.[2]

On warming such a solution, crystals begin to deposit at 43° and at a temperature of 70° constitute one quarter of the bulk of the system. However, a small portion of the solid does not go back into solution, and the solution itself soon becomes very strongly colored (yellow-brown) even when elaborate precautions are taken to avoid contact with the air during the preparation of the ethoxide solution and subsequent sealing of the tube.

Cerous sulfate may be precipitated readily from any of the soluble ceric salts now so widely used in volumetric analysis by adding oxalic acid. The resulting precipitate is thoroughly washed, dried, and then evaporated to dryness with a slight excess of 1:1 sulfuric acid,

$$Ce_2(C_2O_4)_3 + 3H_2SO_4 \longrightarrow Ce_2(SO_4)_3 + 3H_2O + 3CO + 3CO_2$$

The cerous sulfate is purified by heating a saturated solution to 100°, filtering, and washing a few times with boiling water.

TABLE 1

Substance	Weight Dissolved by 100 G. Water at 0°C.	50°C.	100°C.
Calcium chromate, $CaCrO_4$	22.4	18.2	
Calcium hydroxide, $Ca(OH)_2$	0.185	0.10	0.077
Calcium sulfate, $CaSO_4$	0.241		0.222
Cerous sulfate, $Ce_2(SO_4)_3$	19.09	4.78	0.78

* Present address, Harshaw Chemical Company, Cleveland, Ohio.

[1] BABOR, J. A., "General chemistry," Thomas Y. Crowell Co., New York, 1929, pp. 137–8.
HOPKINS, B. S., "Chemistry of the rarer elements," D. C. Heath and Co., New York, 1923, p. 112.
SPENCER, J. F., "The metals of the rare earths," Longmans, Green and Co., London, 1919, pp. 80–2.

[2] JONES, J. H. AND J. S. THOMAS, *J. Chem. Soc.*, 123, 3285–94 (1923).

An APPROACH *to the* THEORY *of* IONIZATION

T. H. HAZLEHURST

Lehigh University, Bethlehem, Pennsylvania

INTRODUCTION

EXISTING treatments of the subject of ionization in elementary texts are open to several criticisms. The usual procedure may be outlined as follows. A classification of matter into mixtures, compounds, and elements is followed by a statement of the laws of definite and multiple proportions and a discussion of Dalton's atomic theory based upon them. With no further effort to show *how atoms unite to form molecules or why valence numbers are integral and specific*, a discussion of the properties of hydrogen, oxygen, and water is entered upon. This serves to lead up to an elementary treatment of the kinetic theory of gases and the phenomenon of vapor pressure.

The development of chemical theory then proceeds via the introduction of solutions and their colligative properties such as vapor pressure and freezing-point lowering and osmotic pressure. It is not until then, when molecules have become stable entities in the mind of the student, that the notion of ionization as a spontaneous decomposition of certain types of molecules is developed. Ionization is portrayed as something unusual and bizarre, because solutions of ionizable substances have "abnormal" colligative properties. At this point the topic of electrolysis is introduced and, despite all efforts to the contrary, the normally disinterested student acquires the difficultly eradicable impression that ionization is an *effect* of, rather than a means of the passage of, the electric current.

It seems worth while to suggest a means of avoiding (1) the mystery surrounding the mechanism of chemical combination and the nature of the valence bond, (2) the introduction of ionization in a sudden and (at least, to the student) illogical fashion, (3) the idea that electrolytic solutions have "abnormal" colligative properties, and (4) the notion that ionization is caused by the passage of a current. In view of the fact that almost all compounds studied in detail by the student of elementary chemistry *are* electrolytes, it is unfortunate that he should receive the impression that they are exceptional. To an upperclassman studying physical chemistry "abnormal" may connote quite correctly a departure from the laws of ideal solutions, but to the beginner it means "out-of-the-way," "unusual," "more or less inexplicable." Hence, he seizes upon the specious idea that the abnormality is caused by the electric current. With a view to remedying these difficulties the following procedure is suggested.

SUGGESTED OUTLINE. PART I. STRONG ELECTROLYTES

Begin by extending Dalton's atomic theory to include electronics. The introduction of electronics at the commencement of a student's career is no longer revolutionary. It has repeatedly been urged by educators desiring to modernize the course in elementary chemistry and surely possesses the advantage of treating the subject logically rather than historically. It has even been adopted by textbooks to a certain extent. Hardly a modern text can be found which does not devote a chapter to radioactivity, atomic structure, and the Bohr and/or Lewis picture of the atom. Unfortuately, such chapters are presented in the nature of digressions, as an introduction of material interesting, no doubt, but of a nature too advanced and abstruse for a young mind which has previously been made familiar with a quite different notion of chemical combination. They are not really *used*. This is a mistake, for it is no more difficult for a student to picture an atom as an orderly arrangement of electrons about a nucleus, the arrangement having a strong tendency to become symmetrical by sharing electrons with, or transferring them to or from, other atoms than to consider it as a unit endowed with a totally mysterious power of combining with other atoms, following rules of valence which are highly arbitrary and inexplicable.

Of course, no detailed treatment of atomic structure is possible or advisable, but it has proved feasible to teach the following points.

1. Atoms are built of layers or shells of electrons arranged about, and held in place by the attraction of, a nucleus, the positive charge on which is the atomic number.

2. Certain electronic configurations are far more stable and far more symmetrical than others. The most stable configurations are those of the atoms of the inert gases He, Ne, etc., which demonstrate their stability by their lack of reactivity.

3. Atoms of other elements have a strong tendency to acquire the stable configuration of the inert gases. They may do so in two ways, (*a*) by giving one or more electrons to, or receiving one or more electrons from, other atoms, in which case both atoms acquire a net electrical charge and are, therefore, attracted by oppositely charged atoms; (*b*) by sharing electrons with other atoms, in which case they are closely bound together, because if either atom tries to leave the group, one or the other must depart from a stable configuration.

4. Atoms held together by virtue of the charges won by electron transfer are said to be bound by "polar" or "ionic" valence, while those held together by shared electrons (usually in pairs) are said to be bound by non-polar valence.*

With his new knowledge of the nature of chemical combination, the student can see readily why the charged atoms tend to form *pairs*, which we usually name molecules, or *larger clusters*, which we call crystals, and can understand that a crystal of sodium chloride is such a cluster—a very large cluster— in which each positive ion is surrounded by negative ones and vice versa. He can see that such a crystal is an assemblage of ions, rather than a group of molecules. He can see that it is perfectly feasible to *separate* the positive and negative ions of a pair without disturbing the symmetry and stability of their respective electron shells. He can see that it is *not* feasible to do the same with the constituent atoms of a molecule such as methane or carbon dioxide, or of a radical such as the sulfate or chlorate radicals, because these are held together by non-polar valence bonds.

It is wise to introduce the term ion long before any mention of electrolytic solutions is in order. Crossword puzzle fans have all learned enough chemistry to know that a charged atom is an ion. Familiarity with the word and with the fact that ions exist quite apart from electrolytic solutions facilitates the introduction of ionization theory later.

From here on the usual procedure of introducing the kinetic theory while discussing the properties of hydrogen, oxygen, and water may be pursued. As the students now have a background of kinetic theory and some vague notions of molecular numbers, sizes, and velocities, solutions may be defined as mixtures in which the components are dispersed and subdivided into their smallest constituent particles—*molecules, atoms, or ions as the case may be.* It is entirely possible to treat the subject of colligative properties by referring to the "solute particles" without specifying their exact nature, or, better, by indicating the diverse possibilities which might be encountered. The presence of 6.062×10^{23} solute particles in one thousand grams of water can be said to lower the freezing point by 1.86°C., to raise the boiling point by 0.52° C., and to produce an osmotic pressure of 22.4 atmospheres.

It may now be pointed out that, as a logical consequence of their electrical charges, the solute particles classified as ions will tend to pair off into molecules. Such a process might conceivably continue until *all* solute ions were paired off, if it were not for an opposing influence. The opposing influence is not a spontaneous separation of the ion-pair, which would be a most inexplicable sort of thing, but the multitudinous and vigorous impacts of the solvent molecules upon the ion-pair. To clarify this view it is advisable to mention the actual number and strength of these impacts. At room temperature, water molecules have an average translational velocity of about 60,000 cm. per second (over 35 miles per second). Since the average intermolecular distance in the solution is only about 3×10^{-8} cm. they undergo about 2×10^{12} collisions with one another or with solute molecules or ions in every second. Many impacts of solvent molecules upon solute ion-pairs will surely be of great force and so directed as to lead to dissociation.† It follows that ion-pairs are of only temporary duration. Of course, the constituent ions, after being separated by impacts of the solvent molecules, may fall again within one another's sphere of influence and reform the ion-pair. Whether this happens or not, there will be many opportunities for them to meet and pair off with *other* ions of opposite charge. In fact, although it is almost out of the question to make even approximate estimates, it is probably the antithesis of exaggeration to say that one individual ion may, in the course of a single second, form and be knocked from thousands of ion-pairs involving scores of different ions. The picture is one of extremely rapid and extremely violent chaotic motion.

It is impossible for the human eye or brain to follow the gyrations of a trillion solute ions among a few hundred trillions of solvent molecules, just as it is impractical to follow the life history of each individual among the 125,000,000 people in the United States. But, just as the insurance actuary can predict accurately the *proportion* (but not the individuals) in any age group who will die in the ensuing year, so the chemist can tell accurately the *average proportion* of ions existing free and the *average proportion* of ion-pairs. He can tell this by observing colligative properties which tell how many *solute particles* are present in a given quantity of solvent. It is clear that ion-pairs should count as only one particle, not two. For instance, if no pairing off occurred, dissolving one hundred sodium ions and one hundred chloride ions in ten thousand molecules of water would produce the same osmotic pressure as dissolving two hundred sucrose molecules in the same quantity of water. Because of the actual pairing, however, the effect of the sodium chloride upon osmotic pressure will not be as great as it would be otherwise. Suppose the solution of sodium chloride has the same effect as a solution of one hundred seventy-five sucrose molecules. Then, obviously, there must be only one hundred seventy-five solute particles in the sodium chloride solution, namely, seventy-five sodium ions, seventy-five chloride ions, and twenty-five ion-pairs which have formed *on the average.* The sodium chloride may thus be said to be twenty-five per cent. un-ionized

* At Lehigh University this material is introduced by supplementing the customary text with a small book (*1*) covering not only the above points but also the application of electron configuration to the explanation of the Periodic Table, and some other introductory work. The book is used for the first seven assignments for the beginning students and has proved most successful. The same end might be attained in a more cumbersome and less satisfactory manner by assigning that portion of the regular text devoted to subatomics and related matter early in the semester and supplementing it with explanatory lectures.

† Of course, in point of fact the ions are surrounded by shells of oriented and partially bound water molecules, but this complication is best omitted from consideration by beginners.

(twenty-five ion-pairs out of a possible one hundred) or, what is the same thing, seventy-five per cent. ionized. In this way the chemist finds from measurements of colligative properties the average degree of ionization of the solute, that is, the extent to which pairing has proceeded on the average.

The words "exceptional" or "abnormal" need never be mentioned in connection with the colligative properties of any solution, electrolytic or not. In truth the exceptional character does not exist. The departure from the ideal solution—a matter utterly unsuited for consideration by or presentation to the elementary student—appears at lower concentrations in electrolytic solutions, but is, of course, by no means absent in non-electrolytic solutions, even as dilute as 0.5 *M*.

There is an answer now for the question frequently raised by students, "Why does sodium chloride ionize?" It does not ionize. The ions tend to associate but are partially prevented by the bombardment of the solvent molecules. An answer is also provided for another question, "If $KClO_3$ ionizes into $K+$ and $(ClO_3)^-$, why does not $(ClO_3)^-$ ionize further?" It will already have been shown that the chlorate radical is bound by non-polar bonds which do not permit the joined atoms to lead independent lives. In no elementary text with which the author is familiar is a really adequate answer to these two questions forthcoming. In the suggested method of presentation the answers are so obvious that the questions are not even asked.

It is easy to extend the picture of the physical process of ionization to include the effect of concentration upon degree of ionization. It will be evident that the number and force of the impacts suffered by a solute ion-pair will depend almost solely upon the temperature, since it will already have been pointed out that all molecules have the same average kinetic energy at the same temperature (illustrated usually by Graham's law of diffusion). Consequently, regardless of changes in concentration, an ion-pair has about the same chance of being broken up as long as the temperature remains the same. So, at a given temperature, the rate of destruction of ion pairs is fixed. This is not true of the rate of formation of ion-pairs, for this rate depends upon the chance of one ion meeting another of opposite charge. Obviously, this chance will be greater the greater the concentration. Hence the rate of formation of ion-pairs is increased by raising the concentration, while the rate of destruction remains the same. The logical consequence is that, on the average, there will be a greater proportion of ion-pairs the greater the concentration; that is, the degree of ionization becomes less as the concentration of the solution becomes greater.

Finally, it is obvious that the presence of quantities of practically independent charged particles in a solution will confer upon the solution the power of conducting electricity, the positive ions going one way and the negative the other under the influence of the imposed potential difference. It is also clear that the more ion-pairs there are, that is, the fewer free ions, the smaller will be the ability of the solution to conduct the current. In other words, the conductivity of the solution, other things being equal, will depend upon the degree of ionization of the solute, and measurements of the conductivity serve as a basis for calculating degree of ionization just as measurements of colligative properties do.

It will be noted that in the proposed treatment emphasis is laid, as it should be, upon the tendency of ions to combine, not upon any hypothetical explosive nature of a molecule of electrolyte. The ion is clearly shown to be the fundamental unit, the molecule a derived one. Furthermore, with this fundamental attitude toward ionization, it is a simple logical development to discuss, in advanced courses, the theories of "complete ionization of strong electrolytes" such as the Debye-Hückel theory. In fact, some unusually alert student may even anticipate this in some measure and of his own accord raise the question which lies at the bottom of all such theories, "How close do ions have to be before they are ion-pairs and not free ions?" It is always a source of delight to a student and an enormous stimulus to his interest to feel that he has been able to anticipate a conclusion not yet reached in class. It gives him the pleasure of making a prediction and having it confirmed at once. On the other hand, when he has been trained to think of the molecule as the fundamental unit and the ion as the exception, it comes as a distasteful and bewildering shock to have to digest an entirely different point of view when he finally encounters the Debye-Hückel theory.

SUGGESTED OUTLINE. PART II. ACIDS AND WEAK ELECTROLYTES

The above treatment of the theory of ionization applied to strong electrolytes may seem inconsistent in that (1) it makes no specific mention of aggregates other than ion-pairs in solution and crystals in the solid state, and (2) it still refers to a "degree of ionization" and obtains values of it from measurements of colligative properties. These inconsistencies are not accidental. It seems far better to familiarize the student with the workings of ionization by using expressions which convey a definite physical picture which is really significant for weak electrolytes, whatever it may be for strong ones.

As typical weak electrolytes the weak acids and the complex ions may be cited. Many papers (*2*, *3*, *4*) have appeared discussing the modern theory of acids and urging the incorporation of this theory into the elementary chemistry course. Since any treatment of ionization must, perforce, treat of acids, a short digression on this topic may be permitted. The basis of the theory is that free protons are as rare in a solution as free electrons are, and that any source of protons is an acid and any acceptor of protons a base. This is an extremely useful extension of the classical ideas on the subject, and makes clear to the student that, for example, acetate ion is a base just as hydroxyl ion is, and also that "hydrogen ion" in aqueous solution is not H^+ but OH_3^+. So much it is wise to present. On the other hand,

the extension of the notion to non-aqueous solvents, while perfectly logical and even eventually necessary, seems likely to defeat its own ends in an elementary course. The fact is that less than one in a thousand solutions handled by freshmen are non-aqueous, and dragging in such solutions deliberately *with no application* other than a possible *ad hoc* laboratory experiment (*3*) is far more likely to confuse than to clarify. After all, *something* must be left to teach in advanced courses, or our superior efficiency will put half of us out of jobs!

To return to the point, it will have been made clear that protons do not exist as such but always attached by non-polar valence bonds to some other atom or radical.* Hence the ionization of acids is fundamentally different from that of salts or hydroxides. The ions formed are not simply parts of an ion-pair previously united but are new things formed by chemical reaction where X^-

$$OH_2 + HX = OH_3^+ + X^-$$

stands for any anion. The reaction is governed by the law of mass action. Of course, if at equilibrium there is a large proportion of OH_3^+ and X^- and relatively little HX, the result is the same as though a salt $(OH_3)X$ (analogous to NH_4Cl) were present, and the corresponding picture of this salt as a strong electrolyte is applicable. But if this is not true—if the acid is weak—then the mass action law, which fails for high concentrations of non-electrolytes and for moderate concentrations of ions, may be applied quantitatively to the reaction.

This opens the way for the introduction of the Ostwald dilution law and the common ion effect if it is thought desirable to include these topics, which are indispensable in presenting any theory of precipitation in qualitative analysis. The usefulness of having a "degree of ionization" of salts such as sodium acetic is manifest in this connection. Any calculation of the hydrogen-ion concentration in a sodium acetate-acetic acid buffer solution must assume *some* such thing.

The writer is aware that the mass action law and such derived quantities as ionization constants and solubility products may be applied rigorously only if the usual concentration terms are replaced by activities, but it is also true that for weak electrolytes and for sparingly soluble substances the ionic concentrations are so low that the activity coefficients are practically unity. The same is not true for the buffer solutions, since here certain ionic concentrations are large, but it seems reasonable to suppose that the *apparent* degree of ionization found from measurements of colligative properties would give approximately correct results in such cases. In any case, the notion of activity is far beyond the beginner.

The second type of weak electrolyte is the complex ion. It is likely that it would be best to confine attention to such complex ions as HCO_3^- or other acid ions, for any introduction of the complex metal ions must of necessity be preceded by a consideration of coördination valence. However, no difficulty is to be experienced (if the time is available) in explaining the low degree of ionization of most of these when it is shown that they are held together by a type of bond intermediate between the ionic and non-polar bonds. Complex metal ions *must* be considered in qualitative analysis and in the chemistry of the heavy metals, and may probably be treated more logically at either of these points than in connection with the theory of ionization.

* The fact that there is a hydride ion, H^-, need not be stressed in elementary chemistry.

SUMMARY

1. The electronic mechanism of valence is early impressed upon the student, the distinction between ionic and non-polar valence being made perfectly clear.

2. The term ion is introduced at this point, long before electrolytic dissociation comes up, and the ionic nature of the crystal lattice of salts is pointed out.

3. With the usual background of elementary kinetic theory, the subject of solutions is broached, ionic solutes being treated exactly like non-electrolytes.

4. Degree of ionization is introduced as a convenient way of expressing degree of *ionic association* which is held up as the fundamental process.

5. Enough of the modern theory of acids and bases is taught to show (1) the absence of free protons, (2) the formation of OH_3^+ in analogy to NH_4^+, and (3) the "ionization" of acids as a chemical process, rather than the reverse of an ionic association.

6. Complex ions of the acid types are treated like acid molecules, but complex ions of the metallic type are best treated separately under "chemistry of the metals" or "qualitative analysis."

CONCLUSION

Finally, it seems in order to add a comment upon the modernization of elementary chemistry demanded and attempted in various places (*4,5,6,7,8,9*). The science is expanding so rapidly that textbooks are inevitably years behind. On the other hand, the problem of what to include in revision is acute. The tendency in modernization has been to include *more physical chemistry* since it is this branch of chemistry which has suffered the most momentous changes and advanced most rapidly. The time allowed for elementary chemistry in the college curriculum, however, has not been increased, and the excess physical chemistry has, perforce, excluded some inorganic, practical, and descriptive chemistry. This is a great pity, and the pedagogical value is dubious. Granted that the comprehension of the nature of atoms, molecules, and interatomic and intermolecular forces should result in a comprehension of all properties of all substances, still our theories are extremely far from this ideal state of development and the student must know *what he is trying to explain* as well as the explanation itself.

Teachers enthusiastic about new discoveries always have a laudable desire to pass them on as soon and as completely as possible, but only so much may be crammed into one year or one semester, and it seems the

reverse of wise to stress the details of new developments at the risk of cutting other material below the desirable minimum. A case in point is the theory of inter ionic attraction. Teachers have known for years that the Ostwald dilution law does not apply to strong electrolytes and that the values of degree of ionization found from conductivity are inconsistent with those found from colligative properties. This has not prevented them from applying the Law of Mass Action to weak electrolytes, and pointing to strong electrolytes as exceptions to the Law. The fact that a more definite explanation of the discrepancy is at hand is no reason why details of the new theory should be offered as material for an elementary course. Thus far, in fact, its achievements, great as they are in perspective against the background of previous knowledge, have been strictly limited to solutions of great dilution and more particularly to solvents of low dielectric constant. It would seem better to limit the new ideas to a presentation such as the one given herewith, where "100 per cent ionization" is not mentioned, but where the purely conventional nature of "degree of ionization" for strong electrolytes is made entirely clear. In the author's opinion, a rearrangement of material and a revision of emphasis might serve the purpose with a minimum of introduction of totally new material with further demands upon time.

It should be remarked that the Editorial of the August, 1936, number of the JOURNAL OF CHEMICAL EDUCATION would seem to indicate that others agree with the present writer that modernization should proceed with a certain conservatism.

LITERATURE CITED

(1) ULLMANN AND NEVILLE, "First assignments in chemistry," revised.
(2) KILPATRICK, M., "Acids, bases, and salts," J. CHEM. EDUC., **12,** 109 (1935), in which occur several further references.
(3) FLOWERS, L. C., "Laboratory method of approach to modern acid-base theory," *ibid.*, **13,** 219 (1936).
(4) GERARD, I. D., "Organization of ideas in general chemistry," *ibid.*, **11,** 650 (1934).
(5) FRENCH, S. J., "Some uses of the polar concept in elementary chemistry," *ibid.*, **13,** 122 (1936).
(6) DEVRIES, J., "Valence and molecular structure," *ibid.*, **13,** 320 (1936).
(7) DAVIDSON, A. W., "Solutions of electrolytes," *ibid.*, **12,** 24 (1935).
(8) WILDMAN, E. A., "The need of modernizing the general course," *ibid.*, **12,** 11 (1935).
(9) HUGGINS, M. L., "Some contributions of crystal structure research to general chemistry teaching," *ibid.*, **13,** 160 (1936).

AN IMPROVED METHOD FOR IGNITING THERMITE REACTIONS

O. C. KLEIN

University of Illinois, Urbana, Illinois

THE customary method for starting a thermite reaction is to place the ignition powder, consisting of an intimate mixture of aluminum powder and barium peroxide, on top of the charge and to ignite by allowing a strip of magnesium ribbon to burn down into the ignition powder. At best, this method does not give the operator much time to retreat to a safe distance; however, its most serious disadvantage lies in the fact that when the magnesium ribbon is being ignited, a glowing piece of it may melt off at the top, fall on the ignition powder, and set it off while the operator's hands are directly over the crucible. Many serious burns have been caused in this manner.

This hazard is eliminated by substituting for the magnesium ribbon a potassium permanganate-glycerine mixture. About 0.25 g. of dry permanganate is finely powdered in a porcelain mortar. This powder is placed in a heap on top of the ignition powder. A small crater is made in it and into this is added one drop of glycerine from the end of a glass rod or a piece of small bore tubing. After a short time a vigorous oxidation of the glycerine by the permanganate occurs, generating sufficient heat to set off the ignition powder. The period of time which elapses before the ignition powder is set off is governed roughly by the thickness of the permanganate layer at the bottom of the crater. A thickness of 1 mm. requires about ten seconds for ignition to take place. The permanganate-glycerine mixture may be used with the usual barium peroxide and aluminum ignition powder.

The above method has been tried out successfully on the various aluminum reductions that usually are included in a course of inorganic preparations. We believe that the use of the permanganate-glycerine mixture will prevent many accidents, particularly if it is necessary to carry out the reductions in the open air, where the presence of a breeze makes it difficult to ignite a magnesium ribbon.

We have found also that the permanganate-glycerine mixture is useful in many other combustion reactions, for example, in starting the oxidation of sugar by potassium chlorate.

An EXPERIMENT *in the* TEACHING *of* HIGH-SCHOOL CHEMISTRY

RICHARD HASKINS, JOHN GAVIN, AND E. C. BOWMAN

DePauw University, Greencastle, Indiana

THEORY UPON WHICH THE PROCEDURE IS BASED

IT IS our belief that the reason why so many high-school students find chemistry somewhat difficult and uninteresting is that abstract ideas are introduced too early and too abruptly. It is assumed that there is a better method of beginning the study—namely, to begin with the "practical" aspects of chemistry as soon as possible and then proceed from these aspects to a consideration of the more abstract textbook materials.

In order to test this theory concerning the high-school situation in chemistry the authors planned and carried out a teaching procedure of the following type. The unit described below is but one of a number of similar units used during a student-teaching period of eleven weeks.

STEPS IN THE PROCEDURE

A unit of work under this procedure is organized in the following eight or nine steps.

(1) An *overview* is prepared and handed to the pupil to be read at the beginning of the very first period devoted to the particular unit. This overview is not intended to give a complete understanding of the material to be taken up in the unit; it is merely a sort of map of what is to be done. Its principal function is simply to give the pupils just enough understanding of what is coming to enable them to view with intelligence the laboratory demonstration which follows immediately, and occupies the remainder of the first period.

(2) A *laboratory demonstration* is the second step and it is so planned as to throw light upon the principal issues to be taken up in the unit, and also in such a way as to raise some questions which may be answered by further experimentation.

(3) As an outgrowth of the laboratory demonstration performed by the teacher, perhaps with the help of an outstanding pupil, *assignments* are made to small groups of pupils, or to individual pupils, of smaller laboratory demonstrations which will supply the answers to the questions raised during the laboratory demonstration, or to other pertinent questions. These demonstrations by the students are to be planned largely by them and are to be set up in the form of problems which they will solve.

(4) After the pupils have their demonstrations prepared they present them before the whole class, in much the same manner as the teacher gave the original demonstration. At the close of any one demonstration, or at the close of all of them, or both, the pupils are privileged to ask questions respecting these demonstrations.

(5) *Compilation of a list of study questions* which are submitted by the students at the close of the demonstrations.

(6) The pupils next *read* in their texts and other references, and seek to discover the answers to these questions.

(7) After this study there is a brief *discussion period* which is usually rather highly socialized in that it is free and informal.

(8) *Final test* over the whole unit.

(9) A possible ninth step is some *reteaching* followed by *retesting* if the results of the test show the need for it. If not, the class proceeds to a new unit.

OUTLINE OF A UNIT, THE ALKALINE EARTH GROUP

Overview

In group II of the periodic system we find the three alkaline-earth metals known as calcium, strontium, and barium. These three elements have a very close family resemblance and have a certain similarity to other alkaline or basic elements, such as potassium and sodium. They are called "earthy" because many of their compounds, especially the carbonates, are insoluble and occur in nature very abundantly. These elements, like the alkali metals (sodium and potassium), have metallic properties. But the oxides of these metals were known long before the metals themselves were discovered. In the early 1800's Sir Humphry Davy succeeded in isolating the alkaline-earth metals, as well as the similar alkaline elements, sodium and potassium.

Of the three elements, calcium is the most abundant, occurring in a variety of compounds as an important constituent of the earth's crust. Calcium compounds are also essential to living organisms, both plant and animal. The metal itself is not of great importance, but important minerals of calcium such as calcite, dolomite, and gypsum are quite familiar in the form of limestone and other rock formations of considerable extent.

Strontium is very similar to calcium in its chemical and physical properties, and thus occurs in similar compounds, though not nearly so abundantly as does calcium. The two minerals, celestite (the sulfate) and strontianite (the carbonate), are the most widely distributed natural compounds of the element. Strontium is familiar as the source of the crimson color in flames of signal fires and fireworks.

Barium in the free state is a silver-white metal which combines readily with the gases, oxygen, hydrogen, and nitrogen when heated in their presence. Although little practical value has been found for the free metal, the carbonate and the sulfate are important chemically.

Since these three metals are so similar it is not unusual, then, to find their compounds of the same type, and we shall become familiar with these compounds, how to prepare them, and how to distinguish these metals and their compounds from one another.

Laboratory Demonstration

Suggestion.—We must remember that calcium is the most important metal in the group we are going to study. Since barium and strontium resemble it very closely, a study of calcium will illustrate many of the properties of the group.

1. Preparation of the metals or elements from their compounds. Under this topic we discussed, and showed on the blackboard, how the metals are prepared commercially. Before going farther we gave a short lecture on electrolysis in general. Then our procedure consisted of:

(*a*) electrolysis of calcium chloride in a graphite crucible (discussed with drawings);

(*b*) electrolysis of strontium chloride with a mercury cathode;

(*c*) electrolysis of barium chloride with a mercury catalyst.

2. We demonstrated how to separate and distinguish these metals by:

(*a*) standard qualitative analytical scheme of separation;

(*b*) flame test (Ca—light red)
(Ba—green)
(Sr—crimson red)

This part was included to show the students how similar salts could be separated and identified. By this method we aroused the curiosity of the pupil.

3. Uses.

(*a*) In fireworks.—Made fireworks, using 5 g. of sugar, 10 g. of powdered $KClO_3$, and 10 g. of calcium or barium or strontium salt. (This last was a short but important experiment, and, as the result was very clear, the students seemed greatly motivated by it.)

INSTRUCTIONS GIVEN TO PUPILS CONCERNING PREPARATION OF THEIR GROUP AND INDIVIDUAL LABORATORY DEMONSTRATIONS

1. Preparation of some compounds of calcium, barium, strontium (group of five pupils)

Object.—To study the preparation of some of the chief compounds of this group.

Procedure.—Plan each part of the experiment so well that everyone in the class will understand what you are doing. While performing the experiment give clear explanations of what is happening and the reasons for the results. Write all necessary equations to help your fellow students see the chemical reaction. Remember that everyone in the class, like yourself, is responsible for what you present and that the experiment is one of the important ways in which one gets information about the subject.

Suggestions.—The leader of the group will arrange the experiment as he sees fit and will assign each member of his group an active part. Try out the experiment so as to have everything in working order and the phenomena well in mind. The leader of the group is responsible for the success of the experiment and should plan the work accordingly.

2. Reactions of the salts of the alkaline earth group (group of four pupils)

Object.—To study the main reactions of the compounds of barium, strontium, and calcium.

Procedure.—Plan each part. . . etc. (As in the first assignment)

3. Hard waters and water-softening (group of four pupils)

Object.—To study the properties of hard waters and the methods by which these waters are softened.

To show.—Properties of temporarily hard water; properties of permanently hard water. Testing hardness of water with soap.

Procedure.—Plan each part. . . etc. (As in the first assignment)

Suggestions.—(*cf.* first assignment)

4. Uses of compounds of the alkaline earths (individual pupil)

Object.—To study the uses of the compounds of barium, calcium, and strontium.

To show.—Uses of plaster of Paris; uses of concrete; the test for sulfate ion; bleaching powder and its properties; use of calcium carbonate in glass manufacturing; use of calcium phosphate as fertilizer.

Procedure.—Plan each part. . . etc. (As in the first assignment)

Suggestions.—You will arrange the experiment alone and carry it out without assistance. Try out the experiment so as to have everything in working order and the phenomena well in mind. Be prepared to answer any questions concerning it. You are responsible for the success of the experiment and should plan your work accordingly.

PRESENTATION OF PUPIL LABORATORY DEMONSTRATIONS

It will be noted that the pupil laboratory demonstrations are so planned as to cover four fields of interest with respect to the materials being studied: first, their preparation; second, their properties; third, their uses in chemistry; fourth, their uses in life generally.

The demonstrations which the pupils made were highly successful. They took much interest both in preparing them and in presenting them to the class as a whole. One of the most noteworthy characteristics of this part of the plan was the type of interest evidenced in the laboratory while the pupils were getting ready their demonstrations. The atmosphere in the laboratory was one of industry, inquiry, and experimentation. It was an exceedingly pleasant contrast to that which had obtained at other times with this same group of pupils.

STUDY QUESTIONS SUBMITTED BY THE PUPILS

1. How are the elements calcium, barium, and strontium prepared commercially?
2. What is the difference between temporarily hard waters and permanently hard waters?
3. How are hard waters softened?
4. What is the difference between limewater and slaked lime?
5. What causes cement to harden?
6. How does plaster of Paris differ from gypsum?
7. How can you use an insoluble phosphate as a fertilizer?
8. How does $CaCl_2$ settle dust?
9. Is chlorine a bleaching agent, or is it the $CaOCl_2$ that does the bleaching?
10. What is witherite?
11. What is the oxalate radical, and from what does it come?
12. Discuss the separation of these elements.
13. Is it true that barium and strontium resemble calcium in their properties?

REFERENCES USED BY THE PUPILS

BLANCHARD, "An Introduction to General Chemistry."
BROWNLEE, FULLER, HANCOCK, SOHON, WHITSIT, "First Principles of Chemistry."
DULL, "Laboratory Exercises in General Chemistry."
LYONS AND CARNAHAN, "Chemistry Workbook."

It seemed to those of us who observed this experiment that the motivation provided by the set-up which has been described up to this point led to a much more intensive type of study than one usually finds. The pupils seemed to see things in their relations and to be less concerned with mere memorization of facts as such.

SOCIALIZED DISCUSSION PERIOD

The pupils entered into the discussion most wholeheartedly. The discussion for the most part indicated

an intrinsic interest in what they were doing and in what they were talking about. There was much less of merely trying to please the teacher.

TEST GIVEN AT THE CLOSE OF THE UNIT

Complete the following statements with the correct answer:

Calcium is prepared commercially by the.....of.....
When calcium is placed in hot water.....and.....are formed.
Temporarily hard waters contain..... and may be softened by..... Permanently hard waters contain.....and may be softened by.....
Quicklime is.....and may be prepared by.....
Limewater is.....but slaked lime is.....
.....is used as fertilizer.
Calcium chloride is a.....substance and this property makes it useful to settle dust.
Bleaching powder may be prepared by passing.....into .....
The formula for the compound formed is.....

Tell in your own words how you would distinguish between two solutions if they were known to be either calcium chloride or barium chloride.

Balance these equations:

$CaCO_3 + CO_2 + H_2O \rightarrow$
$Cl_2 + Ca(OH)_2 \rightarrow$
$MgSO_4 + Na_2CO_3 \rightarrow$
$CaCO_3 \xrightarrow{\text{heated}}$
$Ba(NO_3)_2 + H_2SO_4 \rightarrow$
$CaCl_2 + K_2Cr_2O_7 \rightarrow$
$Ca(HCO_3)_2 + Ca(OH) \rightarrow$
$Ca + H_2O \rightarrow$
$MgSO_4 + Na_2CO_3 + Ca(OH)_2 \rightarrow$
$CaCO_3 + HCl \rightarrow$
Quicklime $+ H_2O \rightarrow$
Bleaching powder $+ HCl \rightarrow$
Ammonium oxalate $+ CaCl_2 \rightarrow$
Calcium bicarbonate $+ Ca(OH)_2 \rightarrow$
Strontium nitrate $+ (NH_4)_2SO_4 \rightarrow$

DISTRIBUTION OF TIME

No doubt it will help the reader to understand more clearly how this unit was carried on to submit a table showing the distribution of time on the various sections of the unit.

First day—15 minutes—reading of overview
45 minutes—teacher demonstration
Second day— 5 minutes—assigning of experiments
55 minutes—preparation of experiments
Third day—35 minutes—finish preparation
25 minutes—1 student demonstration
Fourth day—60 minutes—3 student demonstrations
Fifth day—60 minutes—discussion and supervised study
Sixth day—60 minutes—test

CONCLUSIONS

The class, which consisted of twenty pupils, was too small to warrant statistical summaries as a basis of proof of the conclusions which emerged. However, it may be stated that it is the unanimous judgment of the authors of this article and the critic teacher, Mr. C. B. Edmonson, that much improvement was made as a result of the procedure used, both in terms of achievement and attitude. All of the pupils appeared to take their work in chemistry much more seriously than before and in three cases there was such a marked change as to be very noticeable. Two of the boys who had been somewhat mischievous and rather uninterested changed their attitude to one of attentiveness and interest. One girl who had been doing rather poor work and had exhibited an excess of timidity wound up as the third best pupil in the class, and through her participation in presenting laboratory demonstrations she lost most of her timidity.

To us it seems that the procedure used may have the following advantages;

1. It is pyschologically more in harmony with the way people learn best.
2. It tends to transform laboratory work into a type in which more real experimentation takes place. It is so easy to let laboratory work descend to the cook-book level.
3. It tends to promote intrinsic motivation.
4. It is more economical of chemicals and other materials.
5. It tends to stimulate wider reading in sources other than the text.
6. In spite of the fact that each pupil did somewhat less individual laboratory work than under the old method he appeared to gain more power in planning, executing, and interpreting laboratory experiments than he did under the old method. Whether or not the new procedure really does have these advantages cannot be known until there has been wider experimentation with it.

A NOTE ON THE PREPARATION OF *m*-DINITROBENZENE—A CORRECTION

To the Editor

DEAR SIR:

In the January issue of the JOURNAL my article "A Note on the Preparation of *m*-Dinitrobenzene" appears on page 33. I beg to point out to you that in the fourth line from the bottom, the word *eight* ought to be *eighty*. Kindly include this correction in the next errata list and oblige.

S. V. SHAH

RAJARAN COLLEGE,
KALHAPUR, INDIA

The FERRIC THIOCYANATE EQUILIBRIA*

ROBERT DuBOIS

Fresno State College, Fresno, California

FOR many years, both in this country and abroad, lecturers on chemistry and textbook writers have illustrated their discussions of the important subjects of mass action and chemical equilibrium by showing the reversibility of the reaction between ferric chloride and ammonium thiocyanate in solution, usually represented by the equation

$$FeCl_3 + 3NH_4CNS = Fe(CNS)_3 + 3NH_4Cl$$

The red color produced is attributed to the formation of undissociated, colored molecules of ferric thiocyanate, $Fe(CNS)_3$.

In the lecture demonstrations these two solutions are mixed, and the resulting dark red solution is poured into four separate beakers. The law of mass action is then illustrated by adding to one of the beakers an excess of ferric chloride, to the second an excess of ammonium thiocyanate, and to the third an excess of ammonium chloride, the fourth beaker being kept for reference to compare the color changes produced in the others. In the first two beakers (addition of ferric chloride and ammonium thiocyanate) the concentration of the colored product is increased because of the increased concentration of the reactants, and the red color deepens. In the third case the color fades somewhat as the ammonium chloride is added, and this effect is interpreted as a reversal of the reaction represented above.

Now ferric chloride and ammonium thiocyanate are both strong electrolytes, and their solutions contain principally the ions Fe^{+++}, Cl^-, NH_4^+, and CNS^-. The reaction which occurs when these two solutions are mixed is therefore primarily an ionic reaction which would be more accurately represented by the equation

$$Fe^{+++} + 3CNS^- \longrightarrow Fe(CNS)_3$$

Considerable evidence has been provided in favor of the view that the red-colored product in the ferric thiocyanate reaction is a complex ion, presumably the hexathiocyanatoferriate ion, $Fe(CNS)_6^{---}$. The very convincing evidence offered by Schlesinger and Van Valkenburgh[1] was based on molecular weight determinations of ferric thiocyanate in non-aqueous solvents, on the similarity in the absorption spectra of ferric thiocyanate in water and in ether, and on the electronegative migration of the red component of aqueous ferric thiocyanate solutions.

In further support of the complex ion postulation may be mentioned (1) the large tendency of thiocyanate ion to coördinate with metallic ions and (2) the tendency of the transition elements with incomplete electron subshells, and of iron in particular, to form coördination complexes, usually with a coördination number of six. Table 1 gives a partial list of some of the known thiocyanate complexes.

TABLE 1

SOME COÖRDINATION COMPLEXES OF THIOCYANATE ION

$K_3Fe(CNS)_6$	$K_3Cr(CNS)_6 \cdot 4H_2O$	$K_3Mo(CNS)_6 \cdot 4H_2O$,
$Na_3Fe(CNS)_6 \cdot 12H_2O$	$Na_3Cr(CNS)_6 \cdot 12H_2O$	$Na_3Mo(CNS)_6 \cdot 12H_2O$,
	$(NH_4)_3Cr(CNS)_6 \cdot 4H_2O$	$(NH_4)_3Mo(CNS)_6 \cdot 4H_2O$
	$Ba_3(Cr(CNS)_6)_2 \cdot 16H_2O$	

We shall therefore represent the ferric thiocyanate reaction by the equation

$$Fe^{+++} + 6CNS^- \longrightarrow Fe(CNS)_6^{---}$$

There now arises the question, why should ammonium chloride have the effect of reversing the formation of ferric thiocyanate, which involves neither ammonium nor chloride ions? *It is obvious that the explanation of the decolorizing action of this salt will have to be based on something other than the principle of mass action, which it is traditionally supposed to illustrate.*

THE DECOLORIZING ACTION NOT DUE TO ACIDITY OF SOLUTION ADDED

In looking for indirect ways in which ammonium chloride might affect the ferric thiocyanate equilibrium, the tendency of ammonium salts to hydrolyze suggests that the acidity of the ammonium chloride solution might, in part at least, account for the effect observed. This suggestion must be abandoned, however, for two reasons (1) the conductivity data show that thiocyanic acid is a strong electrolyte, and there is very little tendency for the added hydrogen ion to remove thiocyanate ion as undissociated HCNS; (2) as a matter of fact, H. M. Vernon,[2] de Brouckére and Gillet,[3] and others, have found that the first effect of adding acid to a solution of

* Presented before the Division of Chemical Education at the ninetieth meeting of the A. C. S., San Francisco, California, August 21, 1935.

[1] H. I. SCHLESINGER AND H. B. VAN VALKENBURGH, *J. Am. Chem. Soc.*, **53**, 1212 (1931).

[2] H. M. VERNON, *Chem. News*, **66**, 214 (1892).

[3] L. DE BROUCKÉRE AND A. E. GILLET, *Bull. soc. chim. Belg.*, **42**, 281 (1933).

ferric thiocyanate is to *increase* the color. The effect is due to conversion of the colloidal ferric hydroxide present (formed by hydrolysis of the ferric salt) into free ferric ion available for reaction with thiocyanate ion

$$\begin{array}{l} Fe^{+++} + 6CNS^- \rightleftharpoons Fe(CNS)_6^{---} \\ + \\ 3H_2O \\ \Updownarrow \\ Fe(OH)_3 \\ + \\ 3H^+ \end{array}$$

THE DECOLORIZING ACTION NOT DUE TO SPECIFIC EFFECT OF NH_4^+ OR CL^- IONS

That the decolorizing action of ammonium chloride on ferric thiocyanate solution is not due to any specific effect of either ammonium ion or chloride ion can be shown by comparing the effect of adding equally concentrated solutions of a series of salts such as ammonium chloride, ammonium nitrate, sodium chloride, and sodium nitrate. When the experiment is performed, one observes about the same decrease in color in all cases.

THE DECOLORIZING ACTION PRIMARILY DUE TO ADDITION OF CHARGED IONS (SALT EFFECT)

In the experiment just described it has become apparent that we can effect the apparent reversal of the ferric thiocyanate reaction by adding an electrolyte which has no part at all in the chemical reaction as usually written and which has, indeed, no ion in common with any of the reactants or products. We cannot, therefore, escape the conclusion that *any* salt (not causing precipitation) might have the same effect on the ferric thiocyanate equilibrium as does ammonium chloride.

We find support for this prediction in the fact that many examples have already been found of the influence of neutral salts on reaction velocities and on chemical equilibria between substances with which the added salts do not react directly in a strict chemical sense. Of these examples may be mentioned (*a*) the large increase in the dissociation of weak acids in the presence of salts such as sodium chloride, (*b*) the increased solubility of slightly soluble salts brought about by the addition of foreign electrolytes to the solvent, and (*c*) the effect of neutral salts on the inversion of sucrose catalyzed by acids and on the catalyzed hydrolysis of esters.

These salt effects have been discussed in detail by Bronsted.[4] The effect on the velocity of a reaction between uncharged molecules is proportional to the concentration of the added electrolyte, and this has been called a "linear salt effect." In the case of a reaction involving one or more ions the principal salt effect is proportional to a higher power of the salt concentration than the first and this is, therefore, called an "exponential salt effect." This exponential effect (referred to hereafter simply as "salt effect") is due to a large increase in the ionic atmospheres surrounding the reacting ions and a change in the activities of these ions. The effect of an added salt on the velocity of a given ionic reaction will be measured by the effect on the activity coefficients of the reacting ions.

In the case of the ferric thiocyanate reaction

$$Fe^{+++} + 6CNS^- \rightleftharpoons Fe(CNS)_6^{---}$$

it will be noted that the interionic attraction effect of added salt will tend to alter the activity coefficient of the colored complex product as well as those of the ferric and thiocyanate ions. It is not immediately obvious that the salt effect should be a *decolorizing* effect, that is, that it should hinder the forward reaction more than the reverse. However, that this should be the direction of the effect can be shown in the following way.

We shall first introduce the activity coefficients, f, of the reactants into the expression for the equilibrium constant of the reaction:

$$\frac{(C_{Fe^{+++}} \times f_{Fe^{+++}}) \times (C_{CNS^-} \times f_{CNS^-})^6}{(C_{Fe(CNS)_6^{---}} \times f_{Fe(CNS)_6^{---}})} = K,$$

which rearranges to

$$\frac{C_{Fe^{+++}} \times C^6_{CNS^-}}{C_{Fe(CNS)_6^{---}}} = K \times \frac{f_{Fe(CNS)_6^{---}}}{f_{Fe^{+++}} \times f^6_{CNS^-}}$$

We see that the effect on the apparent dissociation of the colored $Fe(CNS)_6^{---}$ complex is measured by the change in the ratio of the activity coefficients.

If the solutions are sufficiently dilute, we may represent the dependence of the activity coefficients on the salt concentration and the valence type of added salt by the use of the Debye and Hückel limiting law, and the predictions thus made will be at least qualitatively valid for more concentrated solutions. The relation just mentioned is

$$\log f_i = -0.5\, z_i^2 \sqrt{\mu} \text{ or } f_i = 10^{-0.5 z_i^2 \sqrt{\mu}}$$

where f_i and z_i are the activity coefficient and the valence of the ion i, and μ, the ionic strength, is $\frac{1}{2}\Sigma_i\, c_i z_i^2$. When the concentrations of the ionic reactants are small, as is usually the case in the ferric thiocyanate experiments, the ionic strength of the solution is mainly determined by the concentration and valence type of the added salt.

Substitution in the equilibrium expression gives

$$\begin{aligned} \frac{C_{Fe^{+++}} \times C^6_{CNS^-}}{C_{Fe(CNS)_6^{---}}} &= K \times \frac{10^{-0.5(-3)^2\sqrt{\mu}}}{10^{-0.5(3)^2\sqrt{\mu}} \times 10^{-0.5(1)^2\sqrt{\mu}\cdot 6}} \\ &= K \times 10^{3\sqrt{\mu}} \end{aligned}$$

The salt effect is therefore *positive*, at least at low concentrations. That is, with increasing salt concentration, the apparent dissociation of the colored complex is increased and the color of the solution decreases. We shall expect the salt effect to be (*a*) important at low concentrations (because of the exponential nature of the function) and (*b*) more pronounced the higher the valence type.

Both of these expectations are abundantly fulfilled by the results of experiments which have been made under

[4] J. N. BRØNSTED, *Chem. Reviews*, **5**, 231–338 (1928).

the author's direction in the chemical laboratory at Stanford University. Mr. C. L. Flindt has used a photoelectric colorimeter to measure the effects of increasing concentrations of various electrolytes on 0.00375 *M* solutions of ferric thiocyanate. The relative magnitudes of the effects for equal molar concentrations of potassium chloride, potassium sulfate, magnesium chloride, aluminum chloride, and phosphoric acid were just in the order of the ionic strengths of the solutions. The decolorizing action of the higher valence type salts was pronounced at 0.01 *M* concentration and increased rapidly. The effects of hydrochloric acid and sulfuric acid were smaller than those of the corresponding potassium salts, and the difference in each case can be attributed to the effect of hydrogen ion in reversing the hydrolysis of the ferric ion.

Experiments made in the same laboratory by Mr. John Lyman and Mr. Bryce L. Crawford show that chloride solutions have a slightly greater decolorizing action than the corresponding nitrates, presumably because of the formation of the complex hexachloroferriate ion, $FeCl_6^{---}$. Other complex-forming ions, such as oxalate ion, have even more pronounced decolorizing effect on ferric thiocyanate solutions.

The USE *of* STANDARD SODIUM HYDROXIDE SOLUTION *for the* STANDARDIZATION *of* POTASSIUM PERMANGANATE

D. L. SCOLES AND JOSEPH ROTHSTEIN

Long Island University, Brooklyn, New York

A STUDY of the purpose of teaching elementary quantitative analysis brings the instructor to the realization of the fact that of those who enrol in this course, only a small number will do their major college work in chemistry, and a far smaller number will become practicing chemists. The primary thought, then, should be not to teach analysis for itself alone, but rather to teach chemistry through the medium of the approach which quantitative analysis offers.

With this thought in mind, the senior author has for the past eight years had his classes in beginning quantitative analysis standardize permanganate against standard sodium hydroxide solution, using oxalic acid as the "bridge" compound to pass from acid-base to oxidation-reduction standard solutions. The analyses reported by students who had standardized the permanganate in this manner were quite as acceptable as were the analyses of those whose permanganate had been standardized against iron wire.

This being contrary to the dictum that potassium permanganate, which is to be used for the determination of iron, should be standardized against iron of known purity, it seemed advisable to institute a study of the procedure with a view to determining details by which it could best be accomplished, the saving of time which might be effected, and the dependability of the results obtained.

EXPERIMENTAL

Apparatus and chemicals:

Weights, B. S. Certificate B7582.

Buret, B. S. Certificate 1240.

Benzoic acid, B. S. Certificate 39e.

Potassium acid phthalate, B. S. Certificate 84.

Sodium oxalate, B. S. Certificate 406.

Six different samples of oxalic acid:

1. Purified (*1*).
2. Commercial, a very poor grade, so contaminated that it was necessary to filter it before use.
3. United Drug, technical grade.
4. Exeller, a commercial brand.
5. Merck, reagent grade.
6. Eimer and Amend, T. P.

Ten approximately 0.1 *N* solutions of potassium permanganate, prepared by the method of Takio Kato (*2*).

A saturated aqueous solution of phenolphthalein.

Baker and Adamson's C.P. sulfuric acid.

Procedure:

1. A carbonate-free solution of sodium hydroxide was prepared and used by the method of Foulk (*3*) and preserved by the method of Treadwell and Hall (*4*). This solution was standardized against B. S. potassium acid phthalate and B. S. benzoic acid, and found to be 0.2613 normal.
2. Each permanganate solution was standardized against B. S. sodium oxalate.
3. Each permanganate solution was standardized against the standard sodium hydroxide by using each of the six oxalic acid samples as a "bridge," using the following procedure.

A small amount (about 0.25 g., not weighed) of oxalic acid was dissolved in 200 cc. of water, 5.0 cc. of aqueous phenolphthalein was added (an aqueous solution was used because this in no way interfered with the permanganate titration later), and the solution was titrated with the standard sodium hydroxide. This solution, to which had been added 10.0 cc. of (1:1) sulfuric acid, was heated to 85 degrees, and then titrated with permanganate according to the method of McBride (*5*).

Lest the student's error in standardization of sodium hydroxide appear in the potassium permanganate standardization, the instructor titrates each student's sodium hydroxide, giving him the corrected normality of the same, basing the student's grade upon the accuracy of the submitted value. This corrected value is then used by the student for further work. Thus, with the standard sodium hydroxide at hand, the method here outlined is no longer "a very roundabout affair" that "should be employed only as a matter of expediency" (*7*), but rapid and accurate and also serves to

TABLE 1

NORMALITIES OF TEN POTASSIUM PERMANGANATE SOLUTIONS

Sample of Oxalic Acid	*1*	*2*	*3*	*4*	*5*	*6**	*7*	*8*	*9*	*10*	*Mean N of the ten solutions*	*Deviation of the mean from the B. S. value*
Purified	0.1039	0.09897	0.09781	0.1086	0.09831	0.1161	0.1127	0.1045	0.09179	0.08592	0.10186	0.00178
Commercial	0.1029	0.09817	0.09707	0.1069	0.09744	0.1001	0.1057	0.1054	0.09086	0.08620	0.09907	−0.00101
United Drug	0.1033	0.09828	0.09499	0.1072	0.09929	0.1159	0.1059	0.1054	0.09164	0.08549	0.10074	0.00066
Exeller	0.1057	0.09816	0.09239	0.1086	0.09722	0.1258	0.1064	0.1039	0.09137	0.08578	0.10169	0.00161
Merck	0.1065	0.09813	0.09694	0.1160	0.09879	0.0948	0.1065	0.1040	0.09141	0.08602	0.08947	−0.01061
Eimer and Amend	0.1065	0.09816	0.09654	0.1063	0.09753	0.1387	0.0827	0.1050	0.09057	0.08662	0.10086	0.00078
Mean Normality by the six samples	0.1051	0.09831	0.09596	0.1089	0.09809	0.1153	0.1033	0.1047	0.09127	0.08601	0.10069	.....
Normality by the B. S. Standard	0.1023	0.09858	0.09690	0.1068	0.09700	0.1151	0.1057	0.1033	0.08965	0.08542	0.10008	.....
Deviation of Mean from B. S. Standard	0.0028	−0.00027	−0.00094	0.0021	0.0011	0.0001	−0.0024	0.0014	0.0016	0.0006	0.00061	.....
Mean Deviation	0.00250	0.00044	0.00132	0.00250	0.00110	0.01190	0.00528	0.00140	0.00161	0.00059	0.00274	.....

* Subsequent examination showed the presence of manganese dioxide in this solution.

This, of course, gives a direct relationship between the standard sodium hydroxide and the permanganate.

The results of the experimental work are given in Table 1.

Discussion.—Since in a beginning course in volumetric analysis the first standardization is of hydrochloric acid and sodium hydroxide, the latter is then immediately available for the potassium permanganate standardization without further ado.

If the instructor feels that it is not desirable to have the student prepare carbonate-free standard sodium hydroxide, he may substitute standard sulfuric acid for the hydrochloric, and then for standardization of the potassium permanganate solution titrate the oxalic acid with the carbonate-containing sodium hydroxide by boiling out the carbon dioxide by the method of Smith (*6*).

emphasize the two functions of the oxalic acid—as an acid and as a reductant.

Conclusions.—This method of standardizing potassium permanganate possesses the following advantages:

1. A standard carbonate-free solution of sodium hydroxide being available, the permanganate standardization can be completed in a few minutes.
2. Any good grade of oxalic acid is satisfactory as the acid samples are free from oxalate salts and other acid ions.
3. The results are quite as dependable as any other, the deviations being well within the experimental error, bearing in mind that the same experimental errors of the operator occur in the standardization by B. S. materials as in the others. (The purity of the B. S. sodium oxalate could not be assumed to be more than 1 part per 1000, according to the certificate.)

LITERATURE CITED

(1) KOLTHOFF, I. M. AND E. B. SANDELL, "Textbook of quantitative inorganic analysis," The Macmillan Co., New York City, **1936,** p. 525.
(2) KATO, TAKIO, *J. Chem. Soc. Japan,* **48,** 408–10 (1927).
(3) FOULK, C. W., "Notes on quantitative analysis," 3rd edition, The McGraw-Hill Book Co., Inc., New York City, **1914,** p. 122.
(4) TREADWELL, F. P. AND W. P. HALL, "Analytical chemistry," 7th ed., John Wiley & Sons, Inc., New York City, Vol. 2, **1930,** p. 481.
(5) MCBRIDE, R. S., *J. Am. Chem. Soc.,* **34,** 393–416 (1912).
(6) SMITH, G. M., "A course of instruction in quantitative analysis for beginning students," 3rd ed., The Macmillan Co., New York City, p. 114.
(7) FALES, H. A., "Inorganic quantitative analysis," The Century Co., New York City, **1925,** p. 322.

DAILY CHEMICAL ANNIVERSARIES *AS A* TEACHING TOOL*,†

ERNEST H. HUNTRESS

Massachusetts Institute of Technology, Cambridge, Massachusetts

"Commemoration days, festivals which review the past and survey what has been done, are teachers of the future."
F. Haber

✦ ✦ ✦ ✦ ✦ ✦

THIS calendar of the anniversaries of men distinguished for their contributions to chemistry and related sciences has been prepared as the result of the author's hobby of noting the birthdays of those men whose work has come up in the teaching of chemistry, particularly organic chemistry. As the number of entries accumulated, it became evident that a calendar could be prepared such that each day of the year might recall the anniversary of birth (or death) of distinguished contributors to chemistry, or related fields. The present list is offered to teachers, with the belief that by appropriate use of opportunity the material can be used as a teaching tool.

In the scientific periodical literature there is a wealth of biographical material represented in the necrologies, obituaries, and sketches of contemporaries. There is, furthermore, an abundant supply of portraits which in many journals are the finest sort. Unfortunately, this material is not adequately indexed, and it was the original intention to publish with this calendar a brief reference to sources of such pictures in the regular periodical literature available in most scientific libraries. Due to restrictions of journal space, however, the thousands of references collected by the author cannot be printed here.

This calendar includes names both of historical and contemporary interest. An effort was made to obtain data on every worker with whose name some type of reaction, law, principle, unit, method, piece of apparatus, outstanding discovery, industrial achievement, etc., is commonly associated. Both present and past workers in chemistry (organic, inorganic, physical, analytical) are included, together with such of those from the allied fields of physics, mathematics, biology, geology, medicine, and engineering as have contributed to chemical progress. Many names which should be included in such a list have been omitted because data on birthdays were not available. Such entries as are given will serve to provide a focus from which teachers can find inspiration and students can measure the growth of their chemical acquaintance and the breadth of their knowledge.

In view of the impossibility of citing references to specific biographies, it may be desirable to indicate some of the principal sources of biographical studies and portraits in the periodical literature. Perhaps the most fruitful individual source (particularly in organic chemistry) is in the *Berichte der deutschen Chemische Gesellschaft*. The generous allotment of space devoted to biographical purposes and the splendid portraits might well be emulated by other chemical societies. Particular attention should be called to the large special number issued as a part of the *Berichte* for 1918, which includes an index of all biographical memoirs published in that journal up to that time. The *Bulletin de la Société Chimique de France*, the *Journal of the Chemical Society* (*London*), and occasionally the Proceedings section of our own *Journal of the American Chemical Society* are valuable. The Royal Society of London has always carried biographies and portraits of its fellows, and since 1932 these have been issued as a separate journal entitled *Obituary Notices of Fellows of the Royal Society*. The JOURNAL OF CHEMICAL EDUCATION has many articles and portraits and particularly for contemporaries the pages of the *Scientific Monthly* and the American Contemporaries series published by *Industrial and Engineering Chemistry* (since 1934 in the *News Edition*) are invaluable. Other regular journals whose pages have many times proved fertile fields include *Science*, *Nature*, *Naturwissenschaften*, *Zeitschrift für technische Physik*, *Zeitschrift für wissenschaftliche Photographie, Photophysik und Photochemie*, *Transactions of the American Institute of Chemical Engineers* (frontispieces), *Mikrochemie*, *Journal of the Society of Dyers and Colourists*, *Helvetica Chimica Acta*, *Recueil des travaux chimiques des Pays-Bas*, *Chemiker Zeitung*, *Zeitschrift für anorganische und allgemeine Chemie*, *Zeitschrift für analytische Chemie*, *Zeitschrift für Elektrochemie und angewandte physikalische Chemie*, *Chemisch Weekblad*, *Photographische Korrespondenz*, *Journal of the Association of Official Agricultural Chemists*, etc. This list is not intended to be complete but merely suggestive.

Following the usual practice the dates given by the biographers on the basis of the calendars then in use

* Copyright 1937 by Ernest H. Huntress (including text and calendar). Reprints may be obtained at forty cents a single copy and thirty-five cents apiece for copies in lots of two or more from the Journal of Chemical Education, 20th and Northampton Sts., Easton, Pa.

† Contribution No. 150 from the Research Laboratory of Organic Chemistry.

have been retained, except that when the date of birth was definitely stated to be on the Old Style or Julian calendar it has been translated to the New Style or present Gregorian basis. Such cases arise mostly with scientists of Russian origin. No attempt has been made to take account of this calendar difference for other countries, or for any case where no specific designation of the type of calendar was given in the original sources.

In the tables of the calendar a serious effort has been made to establish the accuracy of the dates given. It is surprising how divergent the published information can be, even for as definite a matter as a birthday. Naturally, most cases of this sort are found in the oldest references. The dates of death, cross references to which are included to extend the utility of this compilation, are even more difficult to establish. Many obituary notices fail to specify this important date; sometimes ambiguity arises because death occurred during the night and both of the adjacent days appear according to various accounts. Sometimes only the date of the funeral is given. Sometimes death occurred during a journey to a foreign country with resultant vagueness in the record.

So far as the author is aware there exists no previous calendar of this kind as applied to chemists. Such devices are well recognized in general historical study, and some large encyclopaedias of biography include a conspectus covering the general field. It is hoped that teachers will find this chemical anniversary calendar of interest and value. The author will be grateful for corrections or suggestions, for data with regard to names not appearing in this list, and for illustrations of ways in which the list may prove of value in particular groups.

It is evident that this kind of calendar cannot become obsolete. The facts here included will not change with time. By small effort it can be kept up to date and new names added according to the special interests of each user.

The biographical accounts may be of particular interest to language classes in scientific courses. It is easy to locate material in German, French, Italian, Dutch, and other national journals which is of real interest and great permanent value to the student. Many of the biographies include sections on the chemical work of the scientists and these are particularly interesting and valuable to students with appropriate training. Graduate students reading for language examinations can combine business and pleasure in reading of the life and work of outstanding men.

DAILY ANNIVERSARY CALENDAR FOR CHEMISTS

For each day of the year, the names of those scientists for whom it represents a birthday anniversary are given in full. The year of birth appears in the left hand column; the date of death in the right hand column. To increase the utility of the calendar cross reference is also made to the names of men for whom a given day represents the anniversary of death. This is effected by assigning to each day a serial number, and by printing in parentheses at the right of the date the number of the day of the year under which will be found complete data for such cases.

(1)	*January 1*	(53, 133, 208, 335)	
1852	DEMARCAY, EUGÉNE ANATOLE		—, 1904
1857	LOBRY DE BRUYN, CORNELIUS ADRIAAN		July 23, 1904
(2)	*January 2*	(237, 252)	
1889	ADAMS, ROGER		—
1841	AMAGAT, EMILE HILAIRE		Feb. 15, 1915
(3)	*January 3*	(258)	
1867	MATIGNON, CAMILLE ARTHÈME		Mar. 18, 1934
1872	MOORE, HUGH KELSEA		—
(4)	*January 4*	(125)	
1874	BURGESS, GEORGE KIMBALL		July 2, 1932
1888	KOSSEL, WALTHER		—
1874	TREFLE, JOHN EDGAR		Mar. 23, 1931
(5)	*January 5*	(14, 264, 284)	
1873	BURGESS, CHARLES FREDERICK		—
1842	ENGLER, KARL OSWALD VIKTOR		Feb. 7, 1925
1852	ÉTARD, ALEXANDER LÉON		May 1, 1910
1875	SWAIN, ROBERT ECKLES		—
(6)	*January 6*	(284)	
1872	DORR, JOHN VAN NOSTRAND		—
1890	LINDEMANN, HANS		Mar. 3, 1932
1859	VAN SLYKE, LUCIUS LINCOLN		Sept. 30, 1931
(7)	*January 7*	(15, 83, 213)	
1890	DAVIS, TENNEY LOMBARD		—
1794	MITSCHERLICH, EILHARD		Aug. 28, 1863
1833	ROSCOE, SIR HENRY ENFIELD		Dec. 18, 1915
(8)	*January 8*	(232)	
1851	WEYL, THEODOR		June 6, 1913
1842	WICHELHAUS, HERMANN		Feb. 28, 1927
(9)	*January 9*	(193, 287)	
1869	ABEGG, RICHARD WILHELM HENRICH		Apr. 3, 1910
1860	HERAEUS, WILHELM		—
1857	LIPPMANN, EDMUND OSKAR VON		—
1852	NICHOLS, WILLIAM HENRY		Feb. 21, 1930
1868	SÖRENSON, SÖREN PETER LAURITZ		—
(10)	*January 10*	(100, 146)	
1877	COTTRELL, FREDERICK GARDNER		—
1866	TRAUBE, WILHELM		—
(11)	*January 11*	(182)	
1884	ANDREWS, (MRS.) MARY RUGGLES		Nov. 1, 1934
1875	BECKET, FREDERICK MARK		—
1796	KLAUS, KARL KARLOVICH		Mar. 12, 1864
(12)	*January 12*	(32)	
1857	ÅNGSTROM, KNUT JOHAN		Mar. 4, 1910
1792	ARFVEDSON, JOHANN AUGUST		Oct. 28, 1841
1870	BARTOW, EDWARD		—
1822	CLAUSIUS, RUDOLPH JULIUS EMMANUEL		Aug. 24, 1888
1868	FAY, HENRY		—
1848	SOXHLET, FRANZ		—
(13)	*January 13*	(23, 180, 272, 323)	
1882	BACKER, HILMAR JOHANNES		—
1855	LEHMANN, OTTO		June 26, 1922
1850	MABERRY, CHARLES FREDERIC		June 26, 1927

1826	RITTHAUSEN, KARL HEINRICH LEOPOLD	Oct. 16, 1912
1864	WIEN, WILHELM	Aug. 30, 1928

(14) *January 14* (23, 155, 223, 241)

1851	CLAISEN, LUDWIG	Jan. 5, 1930
1884	JONES, GRINNELL	—
1848	MESSEL, RUDOLPH	Apr. 18, 1920
1861	WESSON, DAVID	May 22, 1934

(15) *January 15* (245, 359)

1869	DAINS, FRANK BURNETT	—
1755	*FOURCROY, ANTOINE FRANCOIS DE	Dec. 16, 1809
1803	RÜHMKORFF, HEINRICH DANIEL	Dec. 19, 1877
1867	WASHINGTON, HENRY STEPHENS	Jan. 7, 1934

(16) *January 16* (232, 340)

1767	EKEBERG, ANDERS GUSTAF	Feb. 11, 1813
1875	MICHAELIS, LEONOR	—

(17) *January 17* (247, 287)

1839	BARTHENAU, LUDWIG BARTH VON	Aug. 3, 1890
1781	HARE, ROBERT	May 15, 1858

(18) *January 18* (166, 281, 346)

1825	FRANKLAND, SIR EDWARD	Aug. 9, 1899
1861	GOLDSCHMIDT, HANS	May 20, 1923

(19) *January 19* (55, 202)

1813	BESSEMER, SIR HENRY	Mar. 13, 1898
1851	EYKMAN, JOHANN FREDERICH	July 1, 1915
1842	LUDWIG, ERNST	Oct. 14, 1915
1838	MARTIUS, CARL ALEXANDER VON	Feb. 26, 1920

(20) *January 20* (126)

1785	GROTHUSS, THEODOR CHRISTIAN JOHANN DIETRICH	Mar. 26, 1822
1871	NORRIS, JAMES FLACK	—
1840	RATHKE, HEINRICH BERNHARD	Aug. 14, 1923
1815	WATTS, HENRY	June 30, 1884

(21) *January 21* (108, 363)

1847	LE BEL, JOSEPH ACHILLE	Aug. 6, 1930
1845	MALLINCKRODT, EDWARD	Feb. 1, 1928
1872	ORTON, KENNEDY JOSEPH PREVITÉ	Mar. 16, 1930
1857	PARR, SAMUEL WILSON	May 16, 1931

(22) *January 22* (179)

1775	AMPÈRE, ANDRÉ MARIE	June 10, 1836
1884	SIMONSEN, JOHN LIONEL	—

(23) *January 23* (336)

1840	ABBÉ, ERNST	Jan. 14, 1905
1842	BEHRENS, HEINRICH	Jan. 13, 1905
1882	BURRELL, GEORGE ARTHUR	—
1876	DIELS, OTTO PAUL HERMANN	—
1872	SULLIVAN, EUGENE CORNELIUS	—
1861	WISLICENUS, WILHELM	June 7, 1922

(24) *January 24* (146, 363)

1875	BLANKSMA, JAN JOHANNES	—
1882	ODDO, BERNARDO	—

(25) *January 25* (91, 278)

1627	BOYLE, ROBERT	Dec. 30, 1691
1861	ZELINSKY, NIKOLAI D.	—

(26) *January 26*

1799	CLAPEYRON, BENOIT PIERRE ÉMILE	Jan. 28, 1864
1886	FREUDENBERG, KARL	—
1881	HUDSON, CLAUDE SILBERT	—

(27) *January 27* (142, 218)

1870	KAHLENBERG, LOUIS ALBERT BERTHOLD	—
1867	OSAKA, YUKICHI RIGAKU-HAKUSHI	—
1843	PURDIE, THOMAS	Dec. 14, 1916

(28) *January 28* (26, 103, 169)

1843	BOLTON, HENRY CARRINGTON	Nov. 19, 1903
1701	CONDAMINE, CHARLES MARIE DE LA	Feb. 4, 1774
1880	FREUNDLICH, HERBERT	—

(29) *January 29* (201, 217)

1861	KNECHT, EDMUND	Dec. 8, 1925
1838	MORLEY, EDWARD WILLIAMS	Feb. 24, 1923

* Some references give June 15.

(30) *January 30* (38)

1862	HENDERSON, GEORGE GERALD	—

(31) *January 31* (211, 271, 360)

1881	LANGMUIR, IRVING	—
1868	RICHARDS, THEODORE WILLIAM	Apr. 2, 1928
1870	WEDEKIND, EDGAR	—

(32) *February 1* (126, 225)

1875	POPE, THOMAS HENRY	Jan. 12, 1936

(33) *February 2* (38, 137, 343)

1802	BOUSSINGAULT, JEAN BAPTISTE JOSEPH DIEUDONNÉ	May 11, 1887

(34) *February 3* (59, 64, 111, 138, 348)

1854	LEPSIUS, BERNHARD	Oct. 7, 1934
1890	SCHERRER, PAUL	—

(35) *February 4* (140, 159)

1896	HICKMAN, KENNETH CLAUDE DEVEREUX	—

(36) *February 5* (44, 199, 298)

1873	DOLEZALEK, FRIEDRICH	Dec. 10, 1920
1872	MENDEL, LAFAYETTE BENEDICT	Dec. 10, 1935
1857	TREADWELL, FREDERICK PEARSON	June 24, 1918

(37) *February 6* (83, 130)

1892	MURPHY, WILLIAM PARRY	—
1890	TAYLOR, HUGH STOTT	—

(38) *February 7* (5, 346)

1882	†GEHLHOFF, GEORG	Mar. 12, 1931
1850	HERRESHOFF, JOHN BROWN FRANCIS	Jan. 30, 1932
1834	MENDELÉEFF, DIMITRI IVANOVITSCH	Feb. 2, 1907

(39) *February 8* (147, 297)

1777	COURTOIS, BERNARD	Sept. 27, 1838
1866	GOMBERG, MOSES	—
1848	JAPP, FRANCIS ROBERT	Aug. 1, 1925
1795	RUNGE, FRIEDLIEB FERDINAND	Mar. 25, 1867

(40) *February 9* (152)

1871	BALY, EDWARD CHARLES CYRIL	—
1700	BERNOUILLI, DANIEL	Mar. 17, 1782 (3)
1864	FORMÁNEK, GAROSLAV	—

(41) *February 10* (86, 95, 137, 337)

1840	CLEVE, PER THEODOR	June 18, 1905
1846	REMSEN, IRA	Mar. 5, 1927
1895	SMYTH, CHARLES PHELPS	—

(42) *February 11* (16, 356)

1864	BOUVEAULT, LOUIS	Sept. 6, 1909
1839	GIBBS, JOSIAH WILLARD	Apr. 28, 1903
1891	ROWE, FREDERIC MAURICE	—

(43) *February 12* (97, 248)

1886	BERGMANN, MAX	—
1813	DANA, JAMES DWIGHT	Apr. 14, 1895
1785	DULONG, PIERRE LOUIS	July 18, 1838
1857	ERDMANN, ERNST	Aug. 17, 1925
1869	ROSENGARTEN, GEORGE DAVID	Feb. 24, 1936

(44) *February 13* (47, 60, 194)

1850	BRÜHL, JULIUS WILHELM	Feb. 5, 1911
1834	CARO, HEINRICH	Sept. 11, 1910
1862	PAUL, THEODOR	Sept. 30, 1928
1807	PELOUZE, THÉOPHILE JULES	May 31, 1867

(45) *February 14* (318)

1889	CRANE, EVAN J.	—
1878	NIEUWLAND, JULIUS ARTHUR	June 11, 1936
1833	OPPENHEIM, ALPHONS	Sept. 16, 1877
1862	POCKELS, AGNES	Nov. 21, 1935
1869	WILSON, CHARLES, THOMSON REES	—

(46) *February 15* (2, 128)

1873	EULER-CHELPIN, HANS VON	—
1861	GUILLAUME, CHARLES EDOUARD	—
1866	LUSK, GRAHAM	July 18, 1932

(47) *February 16*

1826	THOMSEN, JULIUS	Feb. 13, 1908

† Some references give Feb. 6, 1882.

(48) *February 17*

1838 BEILSTEIN, FRIEDRICH KONRAD Oct. 18, 1906

(49) *February 18* (237)

1856 CHITTENDEN, RUSSELL HENRY —
1876 SKITA, ALADAR —

(50) *February 19* (305)

1859 ARRHENIUS, SVANTE Oct. 2, 1927
1841 MCLEOD, HERBERT Oct. 1, 1923
1799 REICH, FERDINAND Apr. 27, 1882
1745 VOLTA, ALESSANDRO Mar. 5, 1827

(51) *February 20* (271, 303)

1844 BOLTZMANN, LUDWIG Sept. 5, 1906
1901 EYRING, HENRY —
1871 MENDENHALL, WALTER CURRAN —

(52) *February 21* (9, 170, 264)

1822 GIBBS, OLIVER WOLCOTT Dec. 9, 1908

(53) *February 22* (334)

1879 BRØNSTED, JOHANNES NICOLAUS —
1866 FOERSTER, FRIEDRICH Sept. 14, 1931
1857 HERTZ, HEINRICH RUDOLPH Jan. 1, 1894
1814 KNAPP, FRIEDRICH LUDWIG June 7, 1904
1886 PLANK, RUDOLPH —
1879 SCHLENK, WILHELM —
1871 SMITH, GEORGE OTIS —

(54) *February 23* (113, 338, 342)

1872 BLAISE, EDMOND ÉMILE —
1865 KREMERS, EDWARD —
1842 LIEBERMANN, CARL THEODOR Dec. 28, 1914
1867 WHITE, WALTER PORTER —

(55) *February 24* (29, 43, 65, 270, 283)

1866 DOW, HERBERT HENRY Oct. 15, 1930
1841 GRAEBE, CARL VON Jan. 19, 1927

(56) *February 25* (284)

1898 ASTBURY, WILLIAM THOMAS —
1869 CROSSLEY, ARTHUR WILLIAM Mar. 5, 1927
1880 LAMB, ARTHUR BECKET —
1869 LEVENE, PHOEBUS AARON THEODORE —

(57) *February 26* (19, 86, 198)

1728 BAUMÉ, ANTOINE (not Beaumé) Oct. 15, 1804
1863 TWITCHELL, ERNST —

(58) *February 27* (270)

1856 EINHORN, ALFRED Mar. 21, 1917
1864 GREEN, ARTHUR GEORGE —

(59) *February 28* (8, 118, 316)

1814 FRÉMY, EDMOND Feb. 3, 1894
1901 PAULING, LINUS CARL —
1683 RÉAUMUR, RENÉ ANTOINE FERCHAULT DE Oct. 17, 1757

(59-A) *February 29*

1852 VONGERICHTEN, EDUARD Aug. 28, 1930

(60) *March 1* (241, 242, 343)

1839 DE CHARDONNET, COUNT LOUIS MARIE HILAIRE BARNIGAUD Mar. 25, 1924
1862 FRANKLIN, EDWARD CURTIS Feb. 13, 1937
1854 VORTMANN, GEORG —

(61) *March 2*

1848 BARBIER, PHILIPPE ANTOINE Sept. 18, 1922
1887 HAUSSER, KARL W. June 4, 1933
1866 WHIPPLE, GEORGE CHANDLER Nov. 27, 1924

(62) *March 3* (6, 199)

1876 BAXTER, GREGORY PAUL —
1709 MARGGRAF, ANDREAS SIGISMUND Aug. 7, 1782
1879 MCCOLLUM, ELMER VERNER —
1843 ROBERTS-AUSTEN, SIR WILLIAM CHANDLER Nov. 22, 1902
1850 SKRAUP, ZDENKO HANS Sept. 10, 1910

(63) *March 4* (12, 128)

1868 CHAMOT, EMILE MONNIN —
1853 POWER, FREDERICK BELDING Mar. 26, 1927
1881 TOLMAN, RICHARD CHACE —

(64) *March 5* (41, 50, 56, 250, 265)

1808 KIPP, PETRUS JACOBUS Feb. 3, 1864
1871 LÜPPO-CRAMER, HENRICUS —

(65) *March 6* (66, 71, 147)

1866 CUSHNY, ARTHUR ROBERTSON Feb. 24, 1926
1787 FRAUNHOFER, JOSEPH June 7, 1826

(66) *March 7*

1862 BOHN, RENÉ Mar. 6, 1922
1869 COHEN, ERNEST JULIUS —
1827 GLADSTONE, JOHN HALL Oct. 6, 1902
1849 HALLER, ALBIN Apr. 29, 1925
1857 HANTZSCH, ARTHUR Mar. 14, 1935
1864 KESTNER, PAUL Apr. 11, 1936
1839 *MOND, LUDWIG Dec. 11, 1909
1857 WAGNER-JAUREGG, J. VON —

(67) *March 8* (296)

1877 BILTZ, WILHELM EUGEN —
1839 CRAFTS, JAMES MASON June 20, 1917
1879 HAHN, OTTO —
1821 MUSPRATT, JAMES SHERIDAN Nov. 14, 1870
1798 WACKENRODER, HEINRICH WILHELM FERDINAND Sept. 4, 1854

(68) *March 9* (130, 226, 327, 330)

1877 ABDERHALDEN, EMIL —
1856 ACHESON, EDWARD GOODRICH July 6, 1931
1847 NIETZKI, RUDOLF Sept. 28, 1917
1846 WARBURG, EMIL GABRIEL July 28, 1931

(69) *March 10*

1852 ANSCHUTZ, RICHARD —
1872 GIBBS, HARRY DRAKE Dec. 28, 1934
1762 RICHTER, JEREMIAS BENJAMIN Apr. 4, 1807

(70) *March 11* (193, 310)

1879 BJERRUM, NIELS —
1818 ST. CLAIRE-DEVILLE, HENRI ÉTIENNE July 1, 1881

(71) *March 12* (11, 38, 277, 279)

1790 DANIELL, JOHN FREDERIC Mar. 13, 1845
1832 FRIEDEL, CHARLES Aug. 20, 1899
1824 KIRCHHOFF, GUSTAV ROBERT Oct. 17, 1887
1838 PERKIN, WILLIAM HENRY (SR.) July 14, 1907
1856 REIMER, KARL LUDWIG Mar. 6, 1921

(72) *March 13* (19, 71, 77, 88)

1878 HÖNIGSCHMIDT, OTTO —
1899 PODBIELNIAK, WALTER JOSEPH —
1834 WALTON, FREDERICK May 16, 1928

(73) *March 14* (66, 193)

1854 EHRLICH, PAUL Aug. 19, 1915
1879 EINSTEIN, ALBERT —
1869 SEYEWETZ, ALPHONSE —

(74) *March 15* (123, 131, 339)

1873 DORSEY, NOAH ERNEST —
1869 SCHRYVER, SAMUEL BARNETT Aug. 21, 1929

(75) *March 16* (21, 249)

1855 EDER, JOSEF MARIA —
1853 KAYSER, HEINRICH GUSTAV JOHANNES —
1787 OHM, GEORG SIMON July 7, 1854

(76) *March 17* (40, 139, 236)

1884 BENEDICT, STANLEY ROSSITER Dec. 22, 1936
1803 LÖWIG, KARL JACOB Mar. 27, 1890

(77) *March 18* (3, 265, 298, 321)

1863 FREUND, MARTIN Mar. 13, 1920
1871 HENRICH, FERDINAND —
1798 ROSE, GUSTAV July 15, 1873
1843 STAEDEL, WILHELM May 14, 1919

(78) *March 19* (272, 315)

1871 BONE, WILLIAM ARTHUR —
1847 CLARKE, FRANK WIGGLESWORTH May 23, 1931
1877 FISCHER, FRANZ —
1883 HAWORTH, WALTER NORMAN —
1900 JOLIOT, FREDERIC —
1881 PRINGSHEIM, PETER —

* Some say May 7, 1839.

1880 TRAUTZ, MAX —
1893 WILSON, ROBERT ERASTUS —

(79) *March 20* (196, 275)

1735 BERGMANN, TOBERN OLOF July 8, 1784
1834 ELIOT, CHARLES WILLIAM Aug. 22, 1926
1880 HILL, ARTHUR EDWARD —
1853 HÜBL, ARTHUR (FREIHERR) VON Apr. 7, 1932

(80) *March 21* (58, 209, 275)

1842 BAUBIGNY, HENRI Oct. 13, 1912
1871 MEYER, HANS —

(81) *March 22* (175, 311)

1856 KONOWALOW, DMITRI PETROVITSCH —
1868 MILLIKAN, ROBERT ANDREWS —
1788 PELLETIER, PIERRE JOSEPHE July 19, 1842

(82) *March 23* (4, 90)

1867 PARSONS, CHARLES LATHROP —
1881 STAUDINGER, HERMANN —

(83) *March 24* (349)

1903 BUTENANDT, ADOLF FRIEDRICH JOHANN —
1884 DEBYE, PETRUS JOSEPHUS WILHELMUS —
1865 LORENZ, HANS —
1811 PÉLIGOT, EUGÈNE MELCHIOR Apr. 15, 1890
1733 PRIESTLY, JOSEPH Feb. 6, 1804
1835 STEFAN, JOSEF Jan. 7, 1893

(84) *March 25* (39, 60)

1863 FLEXNER, SIMON —

(85) *March 26* (20, 63)

1903 BRICKWEDDE, FERDINAND GRAFT —
1838 BROWN, ALEXANDER CRUM Oct. 28, 1922
1893 CONANT, JAMES BRYANT —
1861 DIETZ, RUDOLF —
1877 DILTHEY, WALTHER OTTO —
1753 RUMFORD, COUNT (BENJ. THOMPSON) Aug. 21, 1814
1834 VOGEL, HERMANN WILHELM Dec. 17, 1898

(86) *March 27* (76, 163, 263)

1824 HITTORF, WILHELM Nov. 28, 1914
1847 ROENTGEN, WILHELM CONRAD Feb. 10, 1923
1832 STORER, FRANCIS HUMPHREYS July 30, 1914
1847 WALLACH, OTTO Feb. 26, 1931

(87) *March 28* (110, 324)

1872 DIMROTH, OTTO —
1871 TSCHITSCHIBABIN, ALEXEI EUGENIEWITSCH —

(88) *March 29* (177)

1769 ACCUM, FREDERICH CHRISTIAN June 28, 1838
1875 JOHNSON, TREAT BALDWIN —
1853 THOMSON, ELIHU Mar. 13, 1937
1883 VAN SLYKE, DONALD DEXTER —

(89) *March 30* (252)

(90) *March 31*

1890 BRAGG, WILLIAM LAWRENCE —
1811 BUNSEN, ROBERT WILHELM Aug. 16, 1899
1880 ONSLOW, (MRS.) MURIEL WHELDALE May 19, 1932
1870 POPE, SIR WILLIAM JACKSON —
1860 TRAUBE, J. —
1853 WITT, OTTO NIKOLAUS Mar. 23, 1915

(91) *April 1* (130, 247)

1863 AUTENRIETH, WILHELM LUDWIG Jan. 25, 1926
1850 PECHMANN, HANS VON Apr. 19, 1902
1813 RAMMELSBERG, CARL FRIEDRICH Dec. 28, 1899
1860 REFORMATSKY, SERGIUS NIKOLAJEWITSCH July 28, 1934
1883 SCHAARSCHMIDT, ALFRED Dec. 27, 1932
1865 ZSIGMONDY, RICHARD Sept. 23, 1929

(92) *April 2* (31)

1877 ALSBERG, CARL LUCAS —
1870 HOFMANN, KARL ANDREAS —
1870 JOB, ANDRÉ Aug. 16, 1928

(93) *April 3* (9, 273)

(94) *April 4* (69, 122, 168, 245)

1878 BARGER, GEORGE —
1867 FOLIN, OTTO Oct. 25, 1934

1847 JACKSON, CHARLES LORING Oct. 31, 1935
1848 KLASON, JOHAN PETER —
1822 SIEMENS, KARL WILHELM (SIR WILLIAM) Nov. 19, 1883
1871 WEHNELT, ARTHUR —

(95) *April 5* (332)

1865 BLAU, FRITZ Dec. 5, 1929
1827 LISTER, JOSEPH (LORD) Feb. 10, 1912
1872 PRESCOTT, SAMUEL CATE —

(96) *April 6* (117, 314)

1851 SEUBERT, KARL FRIEDRICH OTTO —
1860 STOLZ, FRIEDRICH —
1863 WALKER, SIR JAMES May 6, 1935

(97) *April 7* (79, 110, 114, 316)

1899 FIESER, LOUIS FREDERICK —
1825 HLASIWETZ, HEINRICH HERMANN CHRISTIAN Oct. 8, 1875
1859 LOEB, JACQUES Feb. 12, 1924
1869 WALKER, WILLIAM HULTZ July 9, 1934

(98) *April 8* (208, 363)

1818 HOFMANN, AUGUST WILHELM VON May 5, 1892
1853 KAHLBAUM, GEORGE WILHELM AUGUST Aug. 28, 1905
1838 STROOF, IGNAZ Nov. 12, 1920
1850 WELCH, WILLIAM HENRY Apr. 30, 1934

(99) *April 9* (127, 243, 258)

1770 SEEBECK, THOMAS JOHANN Dec. 10, 1831
1865 STEINMETZ, CHARLES PROTEUS Oct. 26, 1923

(100) *April 10*

1755 HAHNEMANN, SAMUEL July 2, 1843
1854 ZEISEL, SIMON Jan. 10, 1933

(101) *April 11* (66, 196, 231, 237)

1804 ERDMANN, OTTO LINNÉ Oct. 9, 1869
1861 KÜSTER, FRIEDRICH WILHELM ALBERT June 22, 1917
1890 RIDEAL, ERIC KEIGTHLEY —

(102) *April 12* (319, 356)

1872 URBAIN, GEORGES —
1854 WILL, CARL WILHELM Dec. 30, 1919

(103) *April 13* (178)

1843 CLASSEN, ALEXANDER Jan. 28, 1934
1863 LORENZ, RICHARD June 23, 1929

(104) *April 14* (43, 340)

1629 HUYGHENS, CHRISTIAN June 8, 1695

(105) *April 15* (83, 114, 318, 329, 345)

1834 LUCIUS, EUGEN May 14, 1903
1841 RICHTER, VICTOR VON Oct. 8, 1891
1874 STARK, JOHANNES —

(106) *April 16* (190, 331)

1860 GILDEMEISTER, EDWARD —
1860 KOSTANECKI, STANISLAUS VON Nov. 15, 1910
1838 SOLVAY, ERNEST May 26, 1922

(107) *April 17* (133)

1875 WORDEN, EDWARD CHAUNCEY —

(108) *April 18* (14, 132, 249)

1868 BOGERT, MARSTON TAYLOR —
1838 BOISBAUDRAN, LECOQ DE May 28, 1912
1863 CALLENDAR, HUGH LONGBOURNE Jan. 21, 1930

(109) *April 19* (91, 135)

1883 GLATTFELD, JOHN WILLIAM EDWARD —
1864 HOOKER, SAMUEL COX Oct. 12, 1935
1863 MOUREU, CHARLES LEON FR. June 13, 1929

(110) *April 20* (157, 243, 363)

1836 DRAGENDORFF, JOHANN GEORG NOËL Apr. 7, 1898
1860 GATTERMANN, LUDWIG June 20, 1920
1870 HUNT, REID —
1839 KÖRNER, GUGLIELMO Mar. 28, 1925

(111) *April 21* (256, 349)

1774 BIOT, JEAN BAPTISTE Feb. 3, 1862
1882 BRIDGMAN, PERCY WILLIAMS —
1827 LIMPRICHT, HEINRICH May 13, 1909

1874 OLNEY, LOUIS ATWELL —
1875 PFEIFFER, PAUL —

(112) *April 22*

1851 KOENIGS, WILHELM Dec. 15, 1906

(113) *April 23*

1867 FIBIGER, JOHANNES —
1777 *GAUSS, CARL FRIEDRICH Feb. 23, 1855
1833 GEUTHER, ANTON Aug. 24, 1889
1861 HEYMANN, BERNHARD —
1812 †MILLON, EUGÈNE NICOLAS (AUGUSTE) Oct. 28, 1867
1858 PLANCK, MAX KARL ERNST LUDWIG —

(114) *April 24* (236, 355)

1834 GERNEZ, DÉSIRÉ-JEAN-BAPTISTE Oct. 31, 1910
1863 HORTVET, JULIUS Apr. 7, 1927
1817 MARIGNAC, JEAN CHARLES GALISSARD DE Apr. 14, 1894

(115) *April 25* (152, 222, 331)

1849 KLEIN, CHRISTIAN FELIX June 22, 1925
1862 MIETHE, ADOLF May 5, 1927
1832 STOHMANN, FRIEDRICH CARL ADOLF Nov. 1, 1897

(116) *April 26* (230, 356)

1889 GIUA, MICHELE —
1879 RICHARDSON, OWEN —
1834 SCHIFF, HUGO Sept. 8, 1915

(117) *April 27* (50, 176)

1896 CAROTHERS, WALLACE HUME Apr. 28, 1937
1849 HILL, HENRY BARKER Apr. 6, 1903
1880 JAMES, CHARLES Dec. 10, 1928

(118) *April 28* (42, 117)

1865 JONES, WALTER Feb. 28, 1935
1889 WATERMAN, HEIN IRAEL —

(119) *April 29* (66, 177)

1874 MENSCHUTKIN, BORIS N. —
1893 UREY, HAROLD CLAYTON —
1873 WHITE, ALFRED HOLMES —

(120) *April 30* (98)

1876 MARGOSCHES, BENJAMIN MAX Sept. 26, 1928
1866 PILOTY, OSCAR Oct. 6, 1915

(121) *May 1* (5, 359)

1825 BALMER, JOHANN JAKOB — 1898
1824 WILLIAMSON, ALEXANDER WILLIAM May 6, 1904

(122) *May 2*

1852 GOOCH, FRANK AUSTIN Aug. 12, 1929
1802 MAGNUS, HEINRICH GUSTAV Apr. 4, 1870
1881 SILVERMAN, ALEXANDER —
1868 WOOD, ROBERT WILLIAMS —

(123) *May 3* (143, 175, 184, 225)

1844 ATWATER, WILBUR OLIN Sept. 22, 1907
1860 HALDANE, JOHN SCOTT Mar. 15, 1936

(124) *May 4*

1777 THÉNARD, LOUIS JACQUES June 21, 1857

(125) *May 5* (98, 115, 181)

1811 DRAPER, JOHN WILLIAM Jan. 4, 1882
1851 HEMPEL, WALTER MATHIAS Dec. 1, 1916
1861 HEWITT, PETER COOPER Aug. 25, 1921

(126) *May 6* (96, 121, 257)

1848 ARMSTRONG, HENRY EDWARD —
1859 COHEN, JULIUS BEREND June 14, 1935
1871 GRIGNARD, FRANÇOIS AUGUSTE VICTOR Dec. 13, 1935
1856 LEHNE, OTTO Feb. 1, 1930
1871 MOORE, RICHARD BISHOP Jan. 20, 1931
1848 PROCTER, HENRY RICHARDSON Aug. 17, 1927

(127) *May 7*

1897 HURD, CHARLES DEWITT —
1855 MILLER, OSKAR VON Apr. 9, 1934

(128) *May 8* (238)

1855 BRAUNER, BOHUSLAV Feb. 15, 1935

1864 KEHRMANN, FRIEDRICH JOHAN AUG. LUDWIG Mar. 4, 1929
1873 SIDGWICK, NEVIL VINCENT —

(129) *May 9* (340, 353)

1877 IRVINE, JAMES COLQUHOUN —
1850 WESTON, EDWARD Aug. 20, 1936

(130) *May 10* (170, 194, 332)

1844 FRANCHIMONT, ANTOINE PAUL NICHOLAS July 2, 1919
1788 FRESNEL, AUGUSTIN JEAN July 14, 1827
1830 RAOULT, FRANÇOIS MARIE Apr. 1, 1901
1826 SORBY, HENRY CLIFTON Mar. 9, 1908
1881 WASHBURN, EDWARD WIGHT Feb. 6, 1934

(131) *May 11* (33)

1877 JAEGER, FRANS MAURITS —
1860 SEMMLER, FRIEDRICH WILHELM Mar. 15, 1931

(132) *May 12* (330)

1895 GIAQUE, WILLIAM FRANCIS —
1803 LIEBIG, JUSTUS Apr. 18, 1873
1867 PRAGER, BERNHARD Aug. 30, 1934

(133) *May 13* (111, 351)

1855 GIBSON, JOHN Jan. 1, 1914
1865 THIELE, FRIEDRICH KARL JOHANNES Apr. 17, 1918
1869 THOMPSON, WILLIAM BOYCE June 27, 1930

(134) *May 14* (77, 105, 147)

1886 SPÄTH, ERNST —

(135) *May 15* (17)

1859 CURIE, PIERRE Apr. 19, 1906
1864 TALBOT, HENRY PAUL June 18, 1927

(136) *May 16* (21, 72)

1860 ASCHAN, OSSIAN —
1763 VAUQUELIN, LOUIS NICHOLAS Nov. 15, 1829

(137) *May 17* (249)

1867 BERTRAND, GABRIEL EMILE —
1820 GENTH, FREDERIC AUGUSTUS Feb. 2, 1893
1835 HESSE, JULIUS OSWALD Feb. 10, 1917
1836 LOCKYER, JOSEPH NORMANN Aug. 17, 1920

(138) *May 18*

1850 HEAVISIDE, OLIVER Feb. 3, 1925
1884 LECAT, MAURICE —
1889 MIDGELY, THOMAS, JR. —
1862 STORTENBEKER, WILLEM May 25, 1916

(139) *May 19* (90, 196)

1857 ABEL, JOHN JACOB —
1869 BÜCHERER, HANS THEODOR —
1843 ZINCKE, THEODOR Mar. 17, 1928

(140) *May 20* (18)

1860 BUCHNER, EDWARD Aug. 13, 1917
1878 HERZOG, REGINALD OLIVER Feb. 4, 1935

(141) *May 21* (243, 353)

1860 EINTHOVEN, WILLEM Sept. 28, 1927
1819 PLAYFAIR, LYON (SIR) May 29, 1898

(142) *May 22* (14)

1828 GRAEFE, ALBRECHT VON Aug. 20, 1870
1803 KUHLMANN, KARL FRIEDRICH Jan. 27, 1881

(143) *May 23* (78, 210)

1854 SMITH, EDGAR FAHS May 3, 1928

(144) *May 24* (312, 342)

1686 FAHRENHEIT, DANIEL GABRIEL Sept. 16, 1736
1849 MUNROE, CHARLES EDWARD —
1797 SOUBEIRAN, EUGENE Nov. 17, 1858

(145) *May 25* (138)

1878 GAEDE, WOLFGANG —
1865 ZEEMAN, PIETER —

(146) *May 26* (106, 285)

1865 BILTZ, JOHANN HEINRICH —
1863 DENNIS, LOUIS MUNROE Dec. 9, 1936
1815 GEISSLER, HEINRICH Jan. 24, 1879

* Some references give April 30.
† Some references give April 24.

1865 LE BLANC, MAX —
1882 MEES, CHARLES EDWARD KENNETH —
1867 STIEGLITZ, JULIUS (OSCAR) Jan. 10, 1937

(147) *May 27* (304, 345)

1857 CURTIUS, THEODOR Feb. 8, 1928
1852 DENNSTEDT, MAXIMILIAN EUGEN HERMANN June 19, 1931
1887 FAJANS, KASIMIR —
1854 MYLIUS, FRANZ BENNO Mar. 6, 1931
1840 NILSON, LARS FREDRIK May 14, 1899

(148) *May 28* (108, 347)

1807 AGASSIZ, JEAN LOUIS RODOLPHE Dec. 14, 1873
1836 MITSCHERLICH, ALEXANDER June 1, 1918
1883 OSTWALD, CARL WILHELM WOLFGANG —
1861 TAMMANN, GUSTAV —

(149) *May 29* (141, 351)

1850 GOLDSCHMIEDT, GUIDO Aug. 6, 1915
1856 HARRISON, JOHN BURCHMORE (SIR) —
1878 LEWIS, WINFORD LEE —

(150) *May 30* (341)

1871 CARO, NICODEM —

(151) *May 31* (44, 232)

1876 PATTERSON, AUSTIN MCDOWELL —
1695 PITOT, HENRI Dec. 27, 1771
1862 SACHSE, HERMANN —, 1893

(152) *June 1* (148)

1796 CARNOT, SADI NICHOLAS LÉONHARD Aug. 24, 1832
1842 KRAEMER, GUSTAV WILHELM Feb. 9, 1915
1905 MURPHY, GEORGE MOSELY —
1740 REICHENSTEIN, MÜLLER VON Oct. 12, 1825 (1826?)
1870 SCHMIDT, WILHELM AUGUST Apr. 25, 1927

(153) *June 2*

1879 ROSE, ROBERT EVSTAFIEFF —
1787 SEFSTRÖM, NILS GABRIEL Nov. 30, 1845

(154) *June 3* (256)

1881 BAUDISCH, OSKAR —

(155) *June 4* (61, 321)

1834 VOLHARD, JACOB Jan. 14, 1910
1877 WIELAND, HEINRICH —

(156) *June 5* (210, 336)

1760 GADOLIN, JOHANN Aug. 15, 1852

(157) *June 6* (8, 322, 337)

1850 BRAUN, CARL FERDINAND Apr. 20, 1918

(158) *June 7* (23, 53, 65)

1877 BARKLA, CHARLES GLOVER —
1862 LENARD, PHILLIP EDWARD ANTON —
1828 PFLÜGER, EDUARD FRIEDRICH WILHELM Apr. —, 1910
1865 SLOSSON, EDWIN EMERY Oct. 15, 1929

(159) *June 8* (104)

1851 *NOELTING, DOMINGO EMILIO Aug. 6, 1922
1863 RASCHIG, FRITZ Feb. 4, 1928

(160) *June 9*

1812 FEHLING, HERMANN VON July 1, 1885
1867 MOORE, FORRIS JEWETT Nov. 20, 1926
1860 STOBBÉ, HANS —

(161) *June 10* (22, 244, 350, 365)

1865 ODDO, GIUSEPPE —
1848 TIEMANN, JOHANN KARL WILHELM FERDINAND Nov. 14, 1899

(162) *June 11* (45, 362)

1898 ANDREWS, DONALD HATCH —
1876 GRAY, HARRY LE BRETON July 16, 1936
1851 HEPP, EDWARD June 18, 1917
1857 HOWARD, LELAND OSSIAN —
1842 LINDE, CARL VON Nov. 16, 1934
1867 VORLÄNDER, DANIEL —

* Some references give June 9.

(163) *June 12* (170)

1862 GUYE, PHILLIPPE-AUGUSTE Mar. 27, 1922
1870 VALEUR, AMAND —, 1927

(164) *June 13* (109)

1862 BISTRZYCKI, KARL ANTON AUGUSTIN —
1875 GARVAN, FRANCIS PATRICK —
1831 MAXWELL, JAMES CLERK Nov. 5, 1879
1879 OLIVIER, SIMON CORNELIS JOHANNES —

(165) *June 14* (126)

1736 COULOMB, CHARLES AUGUSTIN Aug. 23, 1806
1868 LANDSTEINER, KARL —
1876 MEISENHEIMER, JAKOB Dec. 2, 1934
1862 NEF, JOHN ULRIC Aug. 13, 1917
1870 SMITS, ANDREAS —

(166) *June 15* (212, 265, 347)

1887 HÄGGLUND, ERIK —
1879 LIND, SAMUEL COLVILLE —
1862 WIENER, OTTO Jan. 18, 1927

(167) *June 16* (320)

1864 STRAUBEL, CONSTANTIN RUDOLF —

(168) *June 17*

1832 CROOKES, SIR WILLIAM Apr. 4, 1919
1860 PERKIN, WILLIAM HENRY, JR. Sept. 17, 1929

(169) *June 18* (41, 135, 162)

1870 BASKERVILLE, CHARLES Jan. 28, 1922
1858 FRIEDHEIM, CARL Aug. 5, 1909
1865 KNOEVENAGEL, HEINRICH EMIL ALBERT Aug. 11, 1921

(170) *June 19* (147, 216, 321)

1854 BORNSTEIN, ERNST GUSTAV Feb. 21, 1932
1866 HESSE, ALBERT May 10, 1924
1862 PERATONER, ALBERTO ANTONIO Nov. 28, 1925
1851 THOMPSON, SILVANUS PHILLIPPS June 12, 1916

(171) *June 20* (67, 110, 190)

1861 HOPKINS, SIR FREDERICK GOWLAND —
1886 PARTINGTON, JAMES RIDDICK —

(172) *June 21* (124, 225, 275, 282)

1875 ROSENTHALER, LEOPOLD —

(173) *June 22* (101, 115, 215)

(174) *June 23* (103)

1843 GROTH, PAUL HEINRICH RITTER VON Dec. 2, 1927

(175) *June 24* (36)

1840 DUCLAUX, PIERRE EMILE May 3, 1904
1885 KEYES, FREDERICK GEORGE —
1867 SPIRO, KARL Mar. 22, 1932
1835 WISLICENUS, JOHANNES Dec. 5, 1902

(176) *June 25*

1862 BAKER, HERBERT BRERETON Apr. 27, 1935
1864 NERNST, WALTHER —

(177) *June 26* (13, 13)

1694 BRANDT, GEORG Apr. 29, 1768
1824 KELVIN, WILLIAM THOMSON Dec. 17, 1907
1872 SCHMIDT, JULIUS Mar. 29, 1933

(178) *June 27* (133, 273)

1841 †GLASER, CARL —
1872 MORGAN, JOHN LIVINGSTON RUTGERS Apr. 13, 1935
1866 PETRENKO-KRITSCHENKO, PAVELNOVITSCH —

(179) *June 28* (88, 362)

1825 ERLENMEYER, RICHARD AUGUST CARL EMIL Jan. 22, 1909
1855 HJELT, EDVARD IMMANUEL July 2, 1921

(180) *June 29*

1870 MCCOY, HERBERT NEWBY —
1833 WAAGE, PETER Jan. 13, 1900

(181) *June 30* (20, 291, 316)

1795 CAVENTOU, BIENAIMÉ May 5, 1877
1803 KESTNER, CHARLES Aug. 12, 1870

† Some references give July 28.

(182) *July 1* (19, 70, 160, 253, 363)

1856 FRESENIUS, THEODOR WILHELM —
1860 PAAL, CARL LUDWIG Jan. 11, 1935

(183) *July 2* (4, 100, 130, 179, 295)

1862 BRAGG, WILLIAM HENRY (SIR) —
1842 LADENBURG, ALBERT Aug. 15, 1911
1864 MCPHERSON, WILLIAM —

(184) *July 3* (267)

1884 EUCKEN, ARNOLD THOMAS —
1835 GRIMAUX, LOUIS EDOUARD May 3, 1900
1872 PATTERSON, THOMAS STEWART —

(185) *July 4* (286, 311)

1853 BECKMANN, ERNST OTTO July 12, 1923

(186) *July 5* (193, 259, 269, 364)

1868 HOWARD, HENRY —
1891 NORTHRUP, JOHN HOWARD —
1852 RECHENBERG, CARL VON —
1839 ROSENSTIEHL, DANIEL AUGUSTE —, 1916

(187) *July 6* (68)

1862 DEVAUX, HENRI —
1869 FICHTER-BERNOULLI, FRITZ —

(188) *July 7* (75)

1877 BERL, ERNST —

(189) *July 8* (79)

1812 FRAZER, JOHN FRIES Oct. 12, 1872

(190) *July 9* (97, 205)

1863 BUCHERER, ALFRED HEINRICH Apr. 16, 1927
1859 HALLWACHS, WILHELM June 20, 1922

(191) *July 10*

1902 ALDER, KURT —
1866 BUCHNER, MAX —
1886 BUNKER, JOHN WYMOND MILLER —

(192) *July 11*

1877 SOMMERFELDT, ERNST —
1860 VAN LAAR, JOHANNES JACOB —

(193) *July 12* (185, 228)

1863 CALMETTE, LÉON CHARLES ALBERT Oct. 29, 1933
1863 DRUDE, PAUL KARL LUDWIG July 5, 1906
1883 DUSHMAN, SAUL —
1854 EASTMAN, GEORGE Mar. 14, 1932
1849 OSLER, SIR WILLIAM Dec. 29, 1919
1857 PICTET, AMÉ Mar. 11, 1937
1853 SCHOTTEN, CARL LUDWIG JOHANNES Jan. 9, 1910

(194) *July 13* (250)

1826 CANNIZZARO, STANISLAO May 10, 1910
1852 OPPENHEIM, FRANZ Feb. 13, 1929

(195) *July 14* (71, 130)

1870 SCHAUM, KARL —
1887 WEIDLEIN, EDWARD RAY —

(196) *July 15* (77, 221, 249, 282, 311)

1871 BODENSTEIN, ERNST AUGUST MAX —
1800 DUMAS, JEAN BAPTISTE ANDRÉ Apr. 11, 1884
1862 HOSKINS, WILLIAM C. May 19, 1934
1820 LAMY, CLAUDE AUGUST Mar. 20, 1878

(197) *July 16* (162)

1876 STOCK, ALFRED EDWARD —

(198) *July 17*

1827 ABEL, SIR FREDERICK Sept. 6, 1902
1849 REVERDIN, FRÉDÉRIC Feb. 26, 1931
1869 STOLLÉ, ROBERT —

(199) *July 18* (43, 46, 214, 228)

1635 HOOKE, ROBERT Mar. 3, 1703
1853 LORENTZ, HENDRIK ANTOON Feb. 5, 1928
1886 OTT, ERWIN —
1870 PAULY, HERMANN —
1847 SADTLER, SAMUEL PHILIP Dec. 20, 1923
1861 STRATTON, SAMUEL WESLEY Oct. 17, 1933

(200) *July 19* (81, 207)

1857 BAMBERGER, EUGEN Dec. 10, 1932
1849 MELDOLA, RAPHAEL Nov. 16, 1915
1877 STÄHLER, ARTHUR —

(201) *July 20*

1832 HOLLEY, ALEXANDER LYMAN Jan. 29, 1882
1846 MEYER, RICHARD E. Nov. 26, 1926
1870 PONZIO, GIACONIO —

(202) *July 21*

1882 REDDELIEN, GUSTAV —
1810 REGNAULT, HENRI VICTOR Jan. 19, 1878

(203) *July 22* (266)

1869 OLSEN, JOHN CHARLES —
1887 HERTZ, GUSTAV —

(204) *July 23* (1, 211, 275)

1885 BUGGE, FRIEDRICH DETLEV GÜNTHER —

(205) *July 24*

1895 BEATTIE, JAMES ALEXANDER —
1853 HARUSSERMANN, CARL July 9, 1918
1851 KAHLBAUM, JOHANNES Aug. 15, 1909

(206) *July 25* (314)

1841 JAFFÉ, MAX Oct. 26, 1912
1883 MOLES, ENRIQUE —
1854 SCHIFF, ROBERT —

(207) *July 26* (242) —

1875 BRAUN, JULIUS VON —
1827 DEBRAY, HENRI JULES July 19, 1888
1863 WALDEN, PAUL

(208) *July 27* (248, 362)

1870 BOLTWOOD, BERTRAM BORDEN Aug. 14, 1927
1848 EÖTVOS, ROLAND VON Apr. 8, 1919
1881 FISCHER, HANS —
1818 HORSFORD, EBEN NORTON Jan. 1, 1893
1865 THOMPSON, GUSTAVE WHYTE —

(209) *July 28* (68, 91)

1810 BOOTH, JAMES CURTIS Mar. 21, 1888
1867 KOMMPPA, GUSTAV —
1861 REISENEGGER, HERMANN Nov. 14, 1930

(210) *July 29* (222)

1893 BOURGUEL, MAURICE June 5, 1932
1869 JONES, LAUDER WILLIAM —
1833 MÜLLER, HUGO May 23, 1915
1877 NEUBERG, CARL —
1882 SHEPPARD, SAMUEL EDWARD —

(211) *July 30* (86)

1822 DEACON, HENRY July 23, 1876
1855 SIEMENS, WILHELM VON Oct. 14, 1919
1841 TOLLENS, BERNHARD CHRISTIAN GOTTFRIED Jan. 31, 1918

(212) *July 31* (228)

1825 BEER, AUGUST Nov. 18, 1863
1855 BODLÄNDER, GUIDO Dec. 25, 1904
1882 IVES, HERBERT EUGENE —
1861 POPP, GEORG —
1879 ROWE, ALLAN WINTER Dec. 6, 1934
1840 SCHULZE, ERNST AUGUST June 15, 1912
1800 WÖHLER, FRIEDRICH Sept. 23, 1882

(213) *August 1* (39, 349)

1864 GILL, AUGUSTUS HERMAN Nov. 11, 1936
1872 MENDENHALL, CHARLES ELWOOD Aug. 18, 1935
1852 WIEDEMANN, EILHARD ERNST GUSTAV Jan. 7, 1928

(214) *August 2*

1815 PIRIA, RAFFAELE July 18, 1865
1776 STROMEYER, FRIEDRICH Aug. 18, 1835

(215) *August 3* (17)

1851 KURBATOW, APOLLON APOLLONOWITSCH June 22, 1903

(216) *August 4* (235, 244)

1852 DOBBIE, SIR JAMES JOHNSTON June 19, 1924
1843 GANS, LEO —
1859 HOWE, JAMES LEWIS —

(217) *August 5* (169, 260)

1866 HARRIES, CARL DIETRICH Nov. 3, 1923
1859 OSBORNE, THOMAS BURR Jan. 29, 1929

(218) *August 6* (21, 149, 159)

1795 ROSE, HEINRICH Jan. 27, 1864
1766 WOLLASTON, WILLIAM HYDE Dec. 22, 1828

(219) *August 7* (62, 241)

1850 HENNIGER, ARTHUR RODOLPHE MARIE Oct. 4, 1884
1802 HESS, GERMAIN HENRI Dec. 12, 1850
1853 MICHAEL, ARTHUR —

(220) *August 8* (251, 279)

1902 DIRAC, PAUL ADRIEN MAURICE —
1779 SILLIMAN, BENJAMIN Nov. 24, 1864

(221) *August 9* (18, 293)

1819 MORTON, WILLIAM THOMAS GREEN July 15, 1868

(222) *August 10* (327)

1673 DIPPEL, JOHANN CONRAD Apr. 25, 1734
1847 TANRET, CHARLES JOSEPH July 29, 1917

(223) *August 11* (169, 360)

1852 DIXON, HAROLD BAILY Sept. 18, 1930
1858 EIJKMAN, CHRISTIAAN —
1836 GULDBERG, CATO MAXIMILIAN Jan. 14, 1902
1860 WEINBERG, ARTHUR VON —

(224) *August 12* (122, 181, 267)

1870 BROWNE, CHARLES ALBERT —
1879 KREMANN, ROBERT KONRAD —
1887 SCHRÖDINGER, ERWIN —

(225) *August 13* (140, 165)

1814 ÅNGSTROM, ANDERS JONAS June 21, 1874
1866 COATES, CHARLES EDWARD —
1876 SCOTT, WILFRED WELDAY May 3, 1932
1819 STOKES, SIR GEORGE GABRIEL Feb. 1, 1903
1872 WILLSTÄTTER, RICHARD MARTIN —

(226) *August 14* (20, 208)

1899 NIEDERL, JOSEPH BERTHOLD —
1777 OERSTED, HANS CHRISTIAN Mar. 9, 1851

(227) *August 15* (156, 183, 205)

1875 KRAUS, CHARLES AUGUST —
1842 TILDEN, SIR WILLIAM AUGUSTUS Dec. 11, 1926

(228) *August 16* (90, 92)

1878 ANTROPOFF, ANDREAS VON —
1863 KIPPING, FREDERICK STANLEY —
1849 KJELDAHL, JOHAN G. C. T. July 18, 1900
1845 LIPPMANN, GABRIEL July 31, or 12, 1921
1886 STEENBOCK, HARRY —
1839 VINCENT, CAMILLE-PHILIPPE —, 1910
1890 WILSON, JOHN ARTHUR —

(229) *August 17* (43, 126, 137, 359)

1884 CLARK, WILLIAM MANSFIELD —
1865 ROSENHEIM, ARTHUR —

(230) *August 18* (213, 214, 351)

1876 DZIEWONSKI, KARL —
1859 GEORGIEVICS, GEORGE CORNELIUS THEODOR VON Apr. 26, 1933
1868 HATSCHEK, EMIL —
1858 SAKURAI, JOJI —

(231) *August 19* (73, 233, 239, 357)

1892 BROGLIE, LOUIS VICTOR DE —
1745 GAHN, JOHANN GOTTLIEB Dec. 8, 1818
1830 MEYER, JULIUS LOTHAR Apr. 11, 1895

(232) *August 20* (71, 129, 142, 304)

1864 ANGELI, ANGELO May 31, 1931
1868 BÖESEKEN, JACOB —
1885 DUFRAISSE, CHARLES ROBERT —
1852 GNEHM, ROBERT —
1847 HOOGEWERFF, SEBASTIAN Jan. 8, 1934
1832 LOWE, THADDEUS SOBIESKI COULINCOURT Jan. 16, 1913

(233) *August 21* (74, 85)

1816 GERHARDT, KARL FRIEDRICH Aug. 19, 1856
1841 HAMMARSTEN, OLOF Sept. 21, 1932

1882 LEWIS, WARREN KENDALL —
1861 RÂY, PRAFULLA CHANDRA (SIR) —
1813 STAS, JEAN SERVAIS Dec. 13, 1891
1820 TYNDALL, JOHN Dec. 4, 1893

(234) *August 22* (79)

1868 WHITNEY, WILLIS RODNEY —

(235) *August 23* (165)

1870 AUERBACH, FRIEDRICH Aug. 4, 1925
1866 HELLER, GUSTAV —

(236) *August 24* (12, 113, 152, 256)

1829 CARIUS, LUDWIG Apr. 24, 1875
1895 KHARASCH, MORRIS SELIG —
1875 ROSENHAIN, WALTER Mar. 17, 1934

(237) *August 25* (125, 265, 340, 349)

1873 BRUNI, GIUSEPPE —
1857 CIAMICIAN, GIACOMO Jan. 2, 1922
1847 MEYER, ERNST SIGISMUND CHRISTIAN VON Apr. 11, 1916
1812 ZININ, NICHOLAI NIKOLAJEWITSCH Feb. 18, 1880

(238) *August 26* (297)

1882 FRANCK, JAMES —
1873 DEFOREST, LEE —
1728 LAMBERT, JOHANN HEINRICH Sept. 25, 1777
1743 LAVOISIER, ANTOINE LAURENT May 8, 1794
1879 LEUCHS, HERMANN —

(239) *August 27*

1874 BOSCH, CARL —
1867 MONTAGNE, PIETER JOHANNES Aug. 19, 1925

(240) *August 28* (7, 59A, 98)

1859 HOLLEMAN, AROLD FREDERICH —
1878 WHIPPLE, GEORGE HOYT —

(241) *August 29* (291)

1855 BERNTHSEN, HEINRICH AUGUST Nov. 26, 1931
1779 BERZELIUS, JÖNS JACOB Aug. 7, 1848
1857 FRIEDLANDER, PAUL Sept. 4, 1923
1834 SPRENGEL, HERMANN JOHANN PHILIP Jan. 14, 1906
1815 VARENTRAPP, FRANZ Mar. 1, 1877

(242) *August 30* (13, 132, 249)

1852 HOFF, JACOBUS HENRICUS VAN'T Mar. 1, 1911
1850 HOFMEISTER, FRANZ July 26, 1922
1877 METZGER, FLOYD JAY —
1856 RUNGE, CARL —
1871 RUTHERFORD, SIR ERNEST —
1884 SVEDBERG, THEODOR —

(243) *August 31*

1786 CHEVREUL, MICHEL-EUGÉNE Apr. 9, 1889
1856 DE FORCRAND, ROBERT HIPPOLYTE Apr. 20, 1933
1821 HELMHOLTZ, HERMANN LUDWIG FERDINAND VON Sept. 8, 1894
1851 OECHSNER DE CONINCK, WILLIAM FRANCOIS —, 1917
1887 PANETH, FRITZ —
1842 PINNER, ADOLF May 21, 1909

(244) *September 1*

1877 ASTON, FRANCIS WILLIAM —
1873 HOPKINS, B. SMITH —
1880 REDMAN, LAWRENCE V. —
1868 VILLIGER, VICTOR June 10, 1934
1858 WELSBACH, CARL AUER VON Aug. 4, 1929

(245) *September 2*

1879 BRAY, WILLIAM CROWELL —
1857 MÖHLAU, B. J. RICHARD —
1853 OSTWALD, WILHELM Apr. 4, 1932
1877 SODDY, FREDERICK —
1854 VIEILLE, PAUL Jan. 15, 1934

(246) *September 3* (285)

1905 ANDERSON, CARL DAVID —
1869 PREGL, FRITZ Dec. 13, 1930

(247) *September 4* (67, 241)

1823 ENGELBACH, THEOPHIL Apr. 1, 1872
1876 EPHRAIM, FRITZ Jan. 17, 1935
1857 LEWKOWITSCH, JULIAN ISIDOR Sept. 16, 1913

(248) *September 5* (51)

1766	DALTON, JOHN	July 27, 1844
1860	EMICH, FRIEDRICH	—
1826	HUNT, THOMAS STERRY	Feb. 12, 1892

(249) *September 6* (42, 198)

1828	BUTLEROW, ALEXANDER MICHAILOWITSCH	May 17, 1886
1870	DONNAN, FREDERICK GEORGE	—
1835	DUPRÉ, AUGUST	July 15, 1907
1829	GRIESS, JOHANN PETER	Aug. 30, 1888
1858	LASSAR-COHN, L.	Oct. —, 1922
1876	MACLEOD, JOHN JAMES RICKARD	Mar. 16, 1935
1732	WILCKE, JOHANN CARL	Apr. 18, 1796

(250) *September 7*

1874	DESCH, CECIL HENRY	—
1829	KEKULÉ, FRIEDRICH AUGUSTE (VON STRADONITZ)	July 13, 1896
1836	TOEPLER (TÖPLER), AUGUST JOSEPH IGNAZ	Mar. 5, 1912

(251) *September 8* (116, 243, 254)

1849	HELL, CARL MAGNUS VON	Dec. 11, 1926
1848	MEYER, VICTOR	Aug. 8, 1897

(252) *September 9*

1866	BROWNING, PHILIP EMBERY	Jan. 2, 1937
1737	GALVANI, LUIGI ALVISIO	Dec. 4, 1798
1847	LEFFMANN, HENRY	Dec. 25, 1930
1862	ORNDORFF, WILLIAM RIPLEY	Nov. 1, 1927
1852	POYNTING, JOHN HENRY	Mar. 30, 1914

(253) *September 10* (62)

1847	ANDREWS, WILLIAM SYMES	July 1, 1929
1892	COMPTON, ARTHUR HOLLY	—
1866	MILLER, WILLIAM LASH	—
1797	MOSANDER, CARL GUSTAV	Oct. 15, 1858
1885	WHERRY, EDGAR THEODORE	—

(254) *September 11* (44)

1865	SMITH, ALEXANDER	Sept. 8, 1922

(255) *September 12*

1897	JOLIOT CURIE, IRENE	—
1851	SCHUSTER, SIR ARTHUR	Oct. 14, 1934

(256) *September 13*

1858	ELBS, KARL	Aug. 24, 1933
1864	MEYERHOFFER, WILHELM	Apr. 21, 1906
1866	NOYES, ARTHUR AMOS	June 3, 1936

(257) *September 14* (53)

1887	COMPTON, KARL TAYLOR	—
1861	EDELEANU, L.	—
1769	HUMBOLDT, FRIEDRICH WILHELM HEINRICH ALEXANDER VON	May 6, 1859
1883	LUCKIESH, MATTHEW	—
1854	NICHOLS, EDWARD LEAMINGTON	—

(258) *September 15* (351)

1839	LUNGE, GEORG	Jan. 3, 1923
1854	SANDMEYER, TRAUGOTT	Apr. 9, 1922

(259) *September 16* (45, 144, 247, 355)

1863	AUWERS, KARL VON	—
1853	KOSSEL, ALBRECHT	July 5, 1927
1893	SZENT-GYÖRGYI, ALBERT	—

(260) *September 17* (168, 281)

1857	BERGMANN, EMIL	Aug. 5, 1922

(261) *September 18* (61, 223)

1854	GLAZEBROOK, RICHARD TETLEY	Dec. 15, 1935
1867	NEWELL, LYMAN CHURCHILL	Dec. 13, 1933

(262) *September 19*

1871	DÉLEPINE, STÉPHANE MARCEL	—

(263) *September 20*

1842	DEWAR, JAMES	Mar. 27, 1923
1876	ELLIS, CARLETON	—

(264) *September 21* (233, 328)

1832	CAILLETET, LOUIS PAUL	Jan. 5, 1913
1853	ONNES, HEIKE KAMERLINGH (Sometimes indexed Kamerlingh-Onnes.)	Feb. 21, 1926

(265) *September 22* (123)

1849	ALBERTONI, PIETRO	Nov. 8, 1933
1791	FARADAY, MICHAEL	Aug. 25, 1867
1827	GUNNING, JAN WILLEM	Jan. —, 1901
1863	KÜSTER, WILLIAM	Mar. 5, 1929
1800	LASSAIGNE, JEAN LOUIS	Mar. 18, 1859
1829	WILLIAMS, GREVILLE	June 15, 1910

(266) *September 23* (91, 212, 365)

1837	GAUTIER, ARMAND EMILE JUSTIN	—, 1920
1855	TAKAMINE, JOKICHI	July 22, 1922

(267) *September 24*

1874	FINDLAY, ALEXANDER	—
1838	LIPPMANN, EDUARD	July 3, 1919
1858	PULFRICH, CARL	Aug. 12, 1927

(268) *September 25* (238)

1853	HERZIG, JOSEPH	—, 1924
1866	MORGAN, THOMAS HUNT	—
1873	OENSLAGER, GEORGE	—

(269) *September 26* (120, 277)

1754	PROUST, JOSEPH LOUIS	July 5, 1826

(270) *September 27* (39)

1818	KOLBE, ADOLPH WILHELM HERMANN	Nov. 25, 1884
1836	LAUTH, CHARLES	Dec. 5, 1913
1849	PAVLOV, IVAN PETROVITCH	Feb. 27, 1936
1857	WOLFF, LUDWIG	Feb. 24, 1919

(271) *September 28* (68, 141, 361)

1871	CAIN, JOHN CANNELL	Jan. 31, 1921
1852	MOISSAN, HENRI	Feb. 20, 1907
1880	SACKUR, OTTO	Dec. 17, 1914

(272) *September 29*

1861	DUISBERG, CARL	Mar. 19, 1935
1829	KRAUT, KARL JOHANN	Jan. 13, 1912
1883	MEYER, KURT	—

(273) *September 30* (6, 44, 290)

1802	BALARD, ANTOINE JÉROME	April 3, 1876
1882	GEIGER, HANS	—
1870	PERRIN, JEAN	—
1865	SCHOLL, ROLAND	—
1834	SCHORLEMMER, CARL	June 27, 1892

(274) *October 1* (50)

1867	BANCROFT, WILDER DWIGHT	—
1868	BREDIG, GEORG	—
1887	WHITMORE, FRANK CLIFFORD	—

(275) *October 2* (50)

1746	HJELM, PETER JACOB	Oct. 7, 1813
1841	JANNASCH, PAUL EHRHARDT	Mar. 20, 1921
1878	LIESCHE, OTTO	Nov. 18, 1931
1791	PETIT, ALEXIS-THERESE	June 21, 1820
1852	RAMSAY, SIR WILLIAM	July 23, 1916
1866	RASSOW, BERTHOLD	—
1826	WIEDEMANN, GUSTAV HEINRICH	Mar. 21, 1899

(276) *October 3*

1870	BENEDICT, FRANCIS GANO	—
1858	FRANKLAND, PERCY FARADAY	—
1863	WOHL, ALFRED	—

(277) *October 4* (219)

1838	LIPPICH, FERDINAND FRANZ	Oct. —, 1913
1858	PUPIN, MICHAEL IDVORSKY	Mar. 12, 1935
1873	TSCHUGAJEFF, LEO ALEXANDROVITSCH	Sept. 26, 1922

(278) *October 5* (308)

1888	HESS, KURT	—
1859	JACOBSON, PAUL HEINRICH	Jan. 25, 1923
1864	LUMIÈRE, LOUIS	—

(279) *October 6* (66, 120)

1853	KRIES, JOHANNES VON	—
1819	THÉNARD, ARNOULD PAUL EDMOND (BARON)	Aug. 8, 1884
1846	WESTINGHOUSE, GEORGE	Mar. 12, 1914

(280) *October 7* (34, 275, 324)

1885	BOHR, NIELS	—
1889	TROPSCH, HANS	Oct. 8, 1935

(281) *October 8* (97, 105, 280, 360)

1850 LE CHATELIER, HENRY L. Sept. 17, 1936
1877 MASCARELLI, LUIGI —
1883 WARBURG, OTTO H. —
1859 WEGSCHEIDER, RUDOLF Jan. 18, 1935

(282) *October 9* (101)

1852 FISCHER, EMIL July 15, 1919
1879 LAUE, MAX VON —
1870 MCILHINEY, PARKER CAIRUS June 21, 1923

(283) *October 10*

1731 CAVENDISH, HENRY Feb. 24, 1810
1832 MALLET, JOHN WILLIAM Nov. 7, 1912

(284) *October 11* (358)

1884 BERGIUS, FRIEDRICH CARL RUDOLF —
1755 DE ELHUYAR, DON FAUSTO Jan. 6, 1833
1855 GAYLEY, JAMES Feb. 25, 1920
1857 GOLDSCHMIDT, KARL Jan. 5, 1926

(285) *October 12* (109, 152, 189, 351)

1827 COOKE, JOSIAH PARSONS Sept. 3, 1894
1865 HARDEN, ARTHUR —
1881 RICHTMYER, FLOYD KARKER —
1812 SOBRERO, ASCANIO May 26, 1888

(286) *October 13* (80)

1837 HÜBNER, HANS (JULIUS ANTON EDWARD) July 4, 1884
1881 JOHNSTON, JOHN —
1806 UNVERDORBEN, OTTO Dec. 28, 1873

(287) *October 14* (19, 211, 255)

1862 JULIUS, PAUL Jan. 9, 1931
1840 KOHLRAUSCH, FRIEDRICH WILHELM GEORG Jan. 17, 1910

(288) *October 15* (55, 57, 158, 253, 342)

1881 MATHEWS, JOSEPH HOWARD —

(289) *October 16* (13)

1875 SHERMAN, HENRY CLAPP —
1868 TONE, FRANK JEROME —

(290) *October 17* (59, 71, 199, 345)

1825 TROOST, LOUIS JOSEPH Sept. 30, 1911

(291) *October 18* (48)

1903 BERGMANN, ERNST —
1799 SCHÖNBEIN, CHRISTIAN FRIEDRICH Aug. 29, 1868
1844 WILEY, HARVEY WASHINGTON June 30, 1930

(292) *October 19*

1862 LUMIÈRE, AUGUSTE —

(293) *October 20*

1826 BLOMSTRAND, CHRISTIAN WILHELM Nov. 5, 1897
1856 RETGERS, JAN WILLEM Aug. 9, 1896

(294) *October 21*

1857 HINSBERG, OSCAR HEINRICH DANIEL —
1833 NOBEL, ALFRED BERNARD Dec. 10, 1896
1809 STENHOUSE, JOHN Dec. 31, 1880

(295) *October 22*

1863 AHRENS, FELIX BENJAMIN Nov. 14, 1910
1843 BABCOCK, STEPHEN MOULTON July 2, 1931
1881 DAVISSON, CLINTON JOSEPH —
1839 ROSSI, AUGUSTE J. —

(296) *October 23*

1852 BALBIANO, LUIGI Mar. 8, 1917
1873 COOLIDGE, WILLIAM DAVID —
1858 CRISMER, LÉON —
1875 LEWIS, GILBERT NEWTON —
1868 MOND, ALFRED M. (LORD MELCHETT) Dec. 27, 1930

(297) *October 24* (353)

1878 FRY, HARRY SHIPLEY —
1632 LEEUWENHOCK, ANTHONY VAN Aug. 26, 1723
1854 ROOZEBOOM, HENDRIK WILLEM BAKHIUS Feb. 8, 1907

(298) *October 25* (94)

1827 BERTHELOT, MARCELIN PIERRE EUGENE Mar. 18, 1907
1842 MENSCHUTKIN, NIKOLAI ALEXANDROVITSCH Feb. 5, 1907

(299) *October 26* (99, 206)

1860 ERRERA, GIORGIO —
1874 LOWRY, THOMAS MARTIN Nov. 2, 1936

(300) *October 27*

1875 HOUBEN, HEINRICH HUBERT MARIA JOSEPH —
1851 VAUGHAN, VICTOR CLARENCE Nov. 21, 1929

(301) *October 28* (12, 85, 113)

1891 ASHDOWN, AVERY ALLEN —

(302) *October 29* (193, 353)

1898 STAUD, CYRIL JEROME —

(303) *October 30* (360)

1855 KILIANI, HEINRICH —
1817 KOPP, HERMANN (FRANZ MORITZ) Feb. 20, 1892

(304) *October 31* (94, 114)

1835 BAEYER, ADOLF VON (JOHANN FRIEDRICH WILHELM) Aug. 20, 1917
1828 SWAN, SIR JOSEPH WILSON May 27, 1914
1832 WELDON, WALTER —, 1885

(305) *November 1* (11, 115, 252)

1857 JOLY, JOHN Dec. 8, 1933
1868 DUNCAN, ROBERT KENNEDY Feb. 19, 1914
1869 LIESEGANG, RAPHAEL EDWARD —

(306) *November 2* (299)

1866 HOFMANN, FRITZ —
1841 WILLGERODT, CONRAD HEINRICH CRISTOPH Dec. 19, 1930

(307) *November 3* (217, 351, 360)

1749 RUTHERFORD, DANIEL Dec. 15, 1819

(308) *November 4*

1806 MOHR, CARL FRIEDRICH Oct. 5, 1879
1862 REESE, CHARLES LEE —

(309) *November 5* (164, 293)

1854 SABATIER, PAUL —

(310) *November 6* (313)

1886 HEILBRON, ISIDOR MORRIS —
1865 KOHLER, ELMER PETER —
1857 NOYES, WILLIAM ALBERT —
1838 RADZISZEWSKI, BRONISLAUS Mar. 11, 1914

(311) *November 7* (283)

1853 ARTH, GEORGES MARIE FLORENT July 15, 1909
1867 CURIE, MARIE SKLODOWSKA July 4, 1934
1851 GABRIEL, SIEGMUND Mar. 22, 1924
1888 RAMAN, CHANDRASEKHARA VENKATA (SIR) —
1873 TIFFENEAU, MARC —

(312) *November 8* (265)

1869 PERKIN, FREDERICK MOLLWO May 24, 1928

(313) *November 9*

1748 BERTHOLLET, CLAUDE LOUIS Nov. 6, 1822
1860 CHATTAWAY, FREDERICK DANIEL —

(314) *November 10* (362)

1861 COMEY, ARTHUR MESSINGER Apr. 6, 1933
1874 EMBDEN, GUSTAV July 25, 1933

(315) *November 11* (213)

1865 JONES, HARRY CLARY Mar. 19, 1916
1869 JORISSEN, WILLEM PAULINUS —
1869 SUDBOROUGH, JOHN J. —

(316) *November 12* (98)

1834 BORODIN, ALEXANDER Feb. 28, 1887
1746 CHARLES, JACQUES ALEXANDRE CÉSAR Apr. 7, 1823
1842 RAYLEIGH, LORD (STRUTT, JOHN WILLIAM) June 30, 1919

(317) *November 13*

1893 DOISY, EDUARD A. —
1894 SHEPHERD, GEORGE MARTIN —

(318) *November 14* (67, 161, 209, 295)

1863 BAEKELAND, LEO HENDRIK —
1891 BANTING, FREDERICK GRANT (SIR) —
1847 FRESENIUS, REMIGIUS HEINRICH Feb. 14, 1920
1807 LAURENT, AUGUSTE Apr. 15, 1853

(319) *November 15* (106, 136, 346)

1843 KÖNIG, J. Apr. 12, 1930

(320) *November 16* (162, 200)

1851 BILLETER, OTTO Dec. 3, 1927
1849 DANA, EDWARD SALISBURY June 16, 1935
1881 HILDEBRAND, JOEL HENRY —
1886 VAIL, JAMES GARRETT —

(321) *November 17* (144)

1865 BURTON, WILLIAM MERRIAM —
1645 LÉMERY, NICHOLAS June 19, 1715
1872 MAILHE, ALPHONSE —, 1932
1856 VENABLE, FRANCIS PRESTON Mar. 18, 1934
1770 WOODHOUSE, JAMES June 4, 1809

(322) *November 18* (212, 275)

1854 HART, EDWARD June 6, 1931
1874 LIPMAN, JACOB GOODALE —

(323) *November 19* (28, 94, 340)

1872 KOPPERS, HEINRICH —
1834 QUINCKE, GEORG HERMANN Jan. 13, 1924
1887 SUMNER, JAMES BATCHELLER —

(324) *November 20* (160)

1873 COBLENTZ, WILLIAM WEBER —
1850 DOEBNER, OSKAR GUSTAV Mar. 28, 1907
1842 HORSTMANN, AUGUST FRIEDRICH Oct. 7, 1929
1877 STORM, CHRISTIAN GEORGE —

(325) *November 21* (45, 300, 332)

1867 IPATIEFF, VLADIMIR N. —

(326) *November 22* (62)

1862 ANDERSON, ALEXANDER PIERCE —

(327) *November 23*

1874 LYMAN, THEODORE —
1887 MOSELY, HENRY GWYN JEFFREYS Aug. 10, 1915
1837 VAN DER WAALS, JOHANNES DIDERIK Mar. 9, 1923

(328) *November 24* (220)

1863 TROUTON, FREDERICK THOMAS Sept. 21, 1922

(329) *November 25* (270)

1818 BABO, CLEMENS HEINRICH LAMBERT VON (FREIHERR) Apr. 15, 1899
1887 HARVEY, EDMUND NEWTON —

(330) *November 26* (201, 241, 361)

1865 HOOKER, ALBERT HUNTINGTON Mar. 9, 1936
1864 VAUBEL, WILHELM —
1817 WURTZ, CHARLES ADOLPHE May 12, 1884

(331) *November 27* (61, 333)

1899 ABRAMSON, HAROLD ALEXANDER —
1701 CELSIUS, ANDERS Apr. 25, 1744
1848 ROWLAND, HENRY AUGUSTUS Apr. 16, 1901

(332) *November 28* (86, 170)

1852 FISCHER, OTTO PHILIP Apr. 5, 1932
1854 HABERLANDT, GOTTLIEB —
1846 HAMONET, MONSEIGNEUR JULES Dec. 4, 1934
1837 HYATT, JOHN WESLEY May 10, 1920
1855 KUHARA, MITSURU Nov. 21, 1919

(333) *November 29*

1876 SUTERMEISTER, EDWIN —
1849 WAGNER, GEORG Nov. 27, 1903

(334) *November 30* (153)

1869 DALEN, NILS GUSTAV —
1871 TER MEULEN, HENRI —
1761 TENNANT, SMITHSON Feb. 22, 1815
1895 WHITMAN, WALTER GORDON —

(335) *December 1* (125)

1743 KLAPROTH, MARTIN HEINRICH Jan. 1, 1817
1861 SCHÖNHERR, OTTO Dec. 24, 1926
1872 THORPE, JOCELYN FIELD —

(336) *December 2* (165, 174)

1895 HARDY, ARTHUR COBB —
1859 KNORR, LUDWIG June 5, 1921
1853 MAQUENNE, LEON G. M. Jan. 23, 1925
1885 MINOT, GEORGE RICHARDS —

(337) *December 3* (320, 364)

1836 LIEBEN, ADOLF June 6, 1914
1818 PETTENKOFER, MAX JOSEPH VON Feb. 10, 1901
1886 SIEGBAHN, KARL MANNE GEORG —

(338) *December 4* (233, 252, 332)

1857 GOLDSCHMIDT, HEINRICH —
1867 HERTY, CHARLES HOLMES —
1878 PLOTNIKOW, IVAN —
1868 PSCHORR, ROBERT FRANZ Feb. 23, 1930

(339) *December 5* (95, 175, 270)

1901 HEISENBERG, WERNER —
1831 LANDOLT, HANS HEINRICH Mar. 15, 1910
1864 MARCKWALD, WILLY —
1868 SOMMERFELD, ARNOLD JOHANNES WILHELM —

(340) *December 6* (212, 347)

1857 BÜLOW, CARL Apr. 14, 1933
1836 CHANDLER, CHARLES FREDERICK Aug. 25, 1925
1835 FITTIG, RUDOLPH Nov. 19, 1910
1778 GAY-LUSSAC, JOSEPH LOUIS May 9, 1850
1863 HALL, CHARLES MARTIN Dec. 27, 1914
1888 KAMM, OLIVER —
1742 LE BLANC, NICOLAS Jan. 16, 1806
1856 MOLISCH, HANS —

(341) *December 7*

1804 ROGERS, WILLIAM BARTON May 30, 1882

(342) *December 8* (29, 231, 305)

1826 SIEMENS, FRIEDRICH May 24, 1904
1845 THORPE, THOMAS EDWARD (SIR) Feb. 23, 1925
1812 WILL, HEINRICH Oct. 15, 1890

(343) *December 9* (52, 146)

1868 HABER, FRITZ Jan. 29, 1934
1848 MILLER, WILHELM VON Mar. 1, 1899

(344) *December 10* (36, 36, 99, 117, 200, 294)

1880 EMDE, HERMANN KARL CHRISTIAN MAXIMILIAN —

(345) *December 11* (66, 227, 251)

1856 BEVAN, EDWARD JOHN Oct. 17, 1921
1855 CROSS, CHARLES FREDERICK Apr. 15, 1935
1843 KOCH, ROBERT May 27, 1910

(346) *December 12* (219)

1846 BAUMANN, EUGEN —, 1896
1853 HILLEBRAND, WILLIAM FRANCIS Feb. 7, 1925
1847 PATERNO DI SESSA, EMANUELE Jan. 18, 1935
1866 WERNER, ALFRED Nov. 15, 1919

(347) *December 13* (126, 233, 246, 261)

1867 BIRKELAND, KRISTIAN June 15, 1917
1854 KNIETSCH, RUDOLPH THEOPHIL JOSEPH May 29, 1906
1816 SIEMENS, ERNST WERNER Dec. 6, 1892

(348) *December 14* (27, 148)

1859 KRÜSS, ALEXANDER GERHARDT Feb. 3, 1895

(349) *December 15* (112, 261, 307)

1852 BECQUEREL, ANTOINE HENRI Aug. 25, 1908
1780 DÖBEREINER, JOHANN WOLFGANG Mar. 24, 1849
1881 HOWE, HARRISON ESTELL —
1863 LITTLE, ARTHUR DEHON Aug. 1, 1935
1884 ROSENMUND, KARL —
1851 SCHULTZ, GUSTAV THEODOR AUGUST OTTO Apr. 21, 1928

(350) *December 16* (15)

1842 GOWLAND, WILLIAM June 10, 1922
1870 WHITAKER, MILTON C. —

(351) *December 17* (85, 177, 271)

1856	BEHREND, ANTON FRIEDRICH ROBERT	Sept. 15, 1926
1778	DAVY, SIR HUMPHRY	May 29, 1829
1797	HENRY, JOSEPH	May 13, 1878
1861	KENNELLY, ARTHUR EDWIN	—
1824	KERR, JOHN	Aug. 18, 1907
1853	ROUX, ÉMILE	Nov. 3, 1933
1818	SMITH, JOHN LAWRENCE	Oct. 12, 1883

(352) *December 18* (7)

1856	THOMSON, SIR JOSEPH JOHN	—

(353) *December 19* (15, 306)

1861	HENDRICK, ELLWOOD	Oct. 29, 1930
1852	MICHELSON, ALBERT ABRAHAM	May 9, 1931
1864	MULLIKEN, SAMUEL PARSONS	Oct. 24, 1934
1742	SCHEELE, CARL WILHELM	May 21, 1786

(354) *December 20* (199)

1891	LUBS, HERBERT AUGUST	—

(355) *December 21*

1805	GRAHAM, THOMAS	Sept. 16, 1869
1839	JUNGFLEISCH, ÉMILE CLÉMENT	Apr. 24, 1916

(356) *December 22* (76, 218)

1870	EVANS, WILLIAM LLOYD	—
1830	GIRARD, AIMÉ	Apr. 12, 1898
1842	GUSTAVSON, GABRIEL	Apr. 26, 1908
1838	MARKOWNIKOW, WLADIMIR WASIBLIEWITSCH	Feb. 11, 1904
1900	SLATER, JOHN CLARKE	—

(357) *December 23*

1702	CRONSTEDT, AXEL FREDRIC	Aug. 19, 1765
1829	SCHUTZENBERGER, PAUL	—, 1897

(358) *December 24* (335)

1888	CURME, GEORGE OLIVER, JR.	—
1818	JOULE, JAMES PRESCOTT	Oct. 11, 1889

(359) *December 25* (212, 252)

1848	BUNTE, HANS HUGO CHRISTIAN	Aug. 17, 1925
1859	DÉNIGES, GEORGES NOÉL FORT	—
1851	FRASCH, HERMANN	May 1, 1914
1845	REIMER, KARL LUDWIG	Jan. 15, 1883
1876	WINDAUS, ADOLF	—

(360) *December 26*

1825	HOPPE-SEYLER, ERNST FELIX IMMANUEL	Aug. 11, 1895
1847	MICHAELIS, KARL ARNOLD AUGUST	Jan. 31, 1916
1852	RIMBACH, EBERHARD	Nov. 3, 1933
1839	SEGER, HERMANN AUGUST	Oct. 30, 1893
1838	WINKLER, CLEMENS ALEXANDER	Oct. 8, 1904

(361) *December 27* (91, 151, 296, 340)

1887	ANDRADE, EDWARD NEVILLE DE COSTA	—
1887	CLARKE, HANS THACHER	—
1846	MICHLER, WILHELM TRAUGOTT	Nov. 26, 1889
1822	PASTEUR, LOUIS	Sept. 28, 1895

(362) *December 28* (54, 69, 91, 286)

1818	FRESENIUS, KARL REMIGIUS	June 11, 1897
1835	GEIKIE, SIR ARCHIBALD	Nov. 10, 1924
1873	HARKINS, WILLIAM DRAPER	—
1766	HISINGER, WILHELM	June 28, 1852
1874	ROSANOFF, MARTIN ANDRÉ	—
1827	THALÉN, TOBIAS ROBERT	July 27, 1905

(363) *December 29* (193)

1885	BROOKS, BENJAMIN TALBOTT	—
1800	GOODYEAR, CHARLES	July 1, 1860
1878	LOEVENHART, ARTHUR SOLOMON	Apr. 20, 1929
1796	POGGENDORFF, JOHANN CHRISTIAN	Jan. 24, 1877
1855	SEDGWICK, WILLIAM THOMPSON	Jan. 21, 1921
1857	YOUNG, SYDNEY	Apr. 8, 1937

(364) *December 30* (25, 102)

1822	KAHLBAUM, AUGUST W.	July 5, 1884
1867	SIMON, LOUIS JACQUES	Dec. 3, 1925

(365) *December 31* (294)

1773	BROWN, ROBERT	June 10, 1858
1668	BOERHAAVE, HERMANN	Sept. 23, 1738
1881	FINK, COLIN GARFIELD	—
1876	PRINGSHEIM, HANS	—

ALPHABETICAL INDEX OF NAMES AND BIRTHDAYS

The figure following the name represents the number of the day in the year under which in the main table will be found the birthday of the corresponding person.

A

ABBÉ 23
ABDERHALDEN 68
ABEGG 9
ABEL, SIR F. 198
ABEL, J. J. 139
ABRAMSON 331
ACCUM 88
ACHESON 68
ADAMS 2
AGASSIZ 148
AHRENS 295
ALBERTONI 265
ALDER 191
ALSBERG 92
AMAGAT 2
AMPÈRE 22
ANDERSON, A. P. 326
ANDERSON, C. D. 246
ANDRADE 361
ANDREWS, D. H. 162
ANDREWS, M. R. 11
ANDREWS, W. S. 253
ANGELI 232
ÅNGSTROM, A. J. 225
ÅNGSTROM, K. J. (son) 12
ANSCHUTZ 69
ANTROPOFF, VON 228
ARFVEDSON 12
ARMSTRONG 126
ARRHENIUS 50
ARTH 311
ASCHAN 136
ASHDOWN 301
ASTBURY 56
ASTON 244
ATWATER 123
AUERBACH 235
AUTENRIETH 91
AUWERS, VON 259

B

BABCOCK 295
BABO, VON 329
BACKER 13
BAEKELAND 318
BAEYER, VON 304
BAKER 176
BALARD 273
BALBIANO 296
BALMER 121
BALY 40
BAMBERGER 200
BANCROFT 274
BANTING 318
BARBIER 61
BARGER 94
BARKLA 158
BARTHENAU, VON 17
BARTOW 12
BASKERVILLE 169
BAUBIGNY 80
BAUDISCH 154
BAUMANN 346
BAUMÉ 57
BAXTER 62
BEATTIE 205
BECKET 11
BECKMANN 185
BECQUEREL 349
BEER 212
BEHREND 351
BEHRENS 23
BEILSTEIN 48
BENEDICT, F. G. 276
BENEDICT, S. R. 76
BERGIUS 284
BERGMANN, EMIL 260
BERGMANN, ERNST 291
BERGMANN, M. 43
BERGMANN, T. O. 79
BERL 188
BERNOUILLI 40
BERNTHSEN 241
BERTHELOT 298
BERTHOLLET 313
BERTRAND 137
BERZELIUS 241
BESSEMER 19
BEVAN 345
BILLETER 320
BILTZ, J. H. 146
BILTZ, W. E. 67
BIOT 111
BIRKELAND 347
BISTRZYCKI 164
BJERRUM 70
BLAISE 54
BLANKSMA 24
BLAU 95
BLOMSTRAND 293
BODENSTEIN 196
BODLÄNDER 212
BÖESEKEN 232
BOERHAAVE 365
BOGERT 108
BOHN 66
BOHR 280
BOISBAUDRAN, DE 108
BOLTON 28
BOLTWOOD 208
BOLTZMANN 51

BONE 78
BOOTH 209
BORNSTEIN 170
BORODIN 316
BOSCH 239
BOURGUEL 210
BOUSSINGAULT 33
BOUVEAULT 42
BOYLE 25
BRAGG, W. H. 183
BRAGG, W. L. 90
BRANDT 177
BRAUN, C. F. 157
BRAUN, J. VON 207
BRAUNER 128
BRAY 245
BREDIG 274
BRICKWEDDE 85
BRIDGMAN 111
BROGLIE, DE 231
BRONSTED 53
BROOKS 363
BROWN, A. C. 85
BROWN, R. 365
BROWNE 224
BROWNING 252
BRÜHL 44
BRUNI 237
BUCHERER, A. H. 190
BUCHNER, E. 140
BUCHNER, M. 191
BÜCHERER, H. T. 139
BÜLOW 340
BUGGE 204
BUNKER 191
BUNSEN 90
BUNTE 359
BURGESS, C. F. 5
BURGESS, G. K. 4
BURRELL 23
BURTON 321
BUTENANDT 83
BUTLEROW 249

C

CAILLETET 264
CAIN 271
CALLENDAR 108
CALMETTE 193
CANNIZZARO 194
CARIUS 236
CARNOT 152
CARO, H. 44
CARO, N. 150
CAROTHERS 117
CAVENDISH 283
CAVENTOU 181
CELSIUS 331
CHAMOT 63
CHANDLER 340
CHARDONNET, DE 60
CHARLES 316
CHATTAWAY 313
CHEVREUL 243
CHITTENDEN 49
CIAMICIAN 237
CLAISEN 14
CLAPEYRON 26
CLARKE, F. W. 78
CLARKE, H. T. 361
CLARK 229
CLASSEN 103
CLAUSIUS 12
CLEVE 41
COATES 225
COBLENTZ 324
COHEN, E. J. 66
COHEN, J. B. 126
COMEY 314
COMPTON, A. H. 253
COMPTON, K. T. 257
CONANT 85
CONDAMINE, DE LA 28
COOKE 285
COOLIDGE 296
COTTRELL 10
COULOMB 165
COURTOIS 39
CRAFTS 67
CRANE 45
CRISMER 296
CRONSTEDT 357
CROOKES 168
CROSS 345
CROSSLEY 56
CURIE, M. S. 311
CURIE, P. 135
CURME 358
CURTIUS 147
CUSHNY 65

D

DAINS 15
DALEN 334
DALTON 248
DANA, E. S. 320
DANA, J. D. 43
DANIELL 71
DAVIS 7
DAVISSON 295
DAVY 351
DEACON 211
DEBRAY 207
DEBYE 83
DE ELHUYAR 284
DE FOREST 238
DÉLEPINE 262
DEMARCAY 1
DÉNIGES 359
DENNIS 146
DENNSTEDT 147
DESCH 250
DEVAUX 187
DEWAR 263
DIELS 23
DIETZ 85
DILTHEY 85
DIMROTH 87
DIPPEL 222
DIRAC 220
DIXON 223
DOBBIE 216
DÖBEREINER 349
DOEBNER 324
DOISY 317
DOLEZALEK 36
DONNAN 249
DORR 6
DORSEY 74
DOW 55
DRAGENDORFF 110
DRAPER 125
DRUDE 193
DUCLAUX 175
DUFRAISSE 232
DUISBERG 272
DULONG 43
DUMAS 196
DUNCAN 305
DUPRÉ 249
DUSHMAN 193
DZIEWONSKI 230

E

EASTMAN 193
EDELEANU 257
EDER 75
EHRLICH 73
EIJKMAN 223
EINHORN 58
EINSTEIN 73
EINTHOVEN 141
EKEBERG 16
ELBS 256
ELIOT 79
ELLIS 263
EMBDEN 314
EMDE 344
EMICH 248
ENGELBACH 247
ENGLER 5
EÖTVOS, VON 208
EPHRAIM, E. 247
ERDMANN, E. 43
ERDMANN, O. L. 101
ERLENMEYER 179
ERRERA 299
ÉTARD 5
EUCKEN 184
EULER-CHELPIN, VON 46
EVANS 356
EYKMAN 19
EYRING 51

F

FAHRENHEIT 144
FAJANS 147
FARADAY 265
FAY 12
FEHLING, VON 160
FIBIGER 113
FICHTER-BERNOULLI 187
FIESER 97
FINDLAY 267
FINK 365
FISCHER, E. 282
FISCHER, F. 78
FISCHER, H. 208
FISCHER, O. P. 332
FITTIG 340
FLEXNER 84
FOERSTER 53
FOLIN 94
FORCRAND, DE 243
FORMÁNEK 40
FOURCROY, DE 15
FRANCHIMONT 130
FRANCK 238
FRANKLAND, SIR E. 18
FRANKLAND, P. F. 276
FRANKLIN 60
FRASCH 359
FRAZER 189
FRAUNHOFER 65
FRÉMY 59
FRESENIUS, R. H. 318
FRESENIUS, K. R. 362
FRESENIUS, T. W. 182
FRESNEL 130
FREUND 77
FREUDENBERG 26
FREUNDLICH 28
FRIEDEL 71
FRIEDHEIM 169
FRIEDLANDER 241
FRY 297

G

GABRIEL 311
GADOLIN 156
GAEDE 145
GAHN 231
GALVANI 252
GANS 216
GARVAN 164
GATTERMANN 110
GAUSS 113
GAUTHIER 266
GAYLEY 284
GAY-LUSSAC 340
GEHLHOFF 38
GEIGER 273
GEIKIE 362
GEISSLER 146
GENTH 137
GEORGIEVICS, VON 230
GERHARDT 233
GERNEZ 114
GEUTHER 113
GIAQUE 132
GIBBS, H. D. 69
GIBBS, J. W. 42
GIBBS, O. W. 52
GIBSON, J. 133
GILDEMEISTER 106
GILL 213
GIRARD 356
GIUA 116
GLADSTONE 66
GLASER 178
GLATTFELD 109
GLAZEBROOK 261
GNEHM 232
GOLDSCHMIDT, HANS 18
GOLDSCHMIDT, HEINRICH 338
GOLDSCHMIDT, K. 284
GOLDSCHMIEDT, G. 149
GOMBERG 39
GOOCH 122
GOODYEAR 363
GOWLAND 350
GRAEBE 55
GRAEFE, VON 142
GRAHAM 355
GRAY 162
GREEN 58
GRIESS 249
GRIGNARD 126
GRIMAUX 184
GROTH, VON 174
GROTHUSS 20
GUILLAUME 46
GULDBERG 223
GUNNING 265
GUSTAVSON 356
GUYE 163

H

HABER 343
HABERLANDT 332
HAEUSSERMANN 205
HÄGGLUND 166
HAHN 67
HAHNEMANN 100
HALDANE 123
HALL 340
HALLER 66
HALLWACHS 190
HAMMARSTEN 233
HAMONET 332
HANTZSCH 66
HARDEN 285
HARDY 336
HARE 17
HARKINS 362
HARRIES 217
HARRISON 149
HART 322
HARVEY 329
HATSCHEK 230
HAUSSER 61
HAWORTH 78
HEAVISIDE 138
HEILBRON 310
HEISENBERG 339
HELL, VON 251
HELLER 235
HELMHOLTZ, VON 243
HEMPEL 125
HENDERSON 30
HENDRICK 353
HENNIGER 219
HENRICH 77

HENRY 351
HEPP 162
HERAEUS 9
HERRESHOFF 38
HERTY 338
HERTZ, G. 203
HERTZ, H. 53
HERZIG 268
HERZOG 140
HESS, G. H. 219
HESS, K. 278
HESSE, A. 170
HESSE, J. O. 137
HEWITT 125
HEYMAN 113
HICKMAN 35
HILDEBRAND 320
HILL, A. E. 79
HILL, H. B. 117
HILLEBRAND 346
HINSBERG 294
HISINGER 362
HITTORF 86
HJELM 275
HJELT 179
HLASIWETZ 97
HÖNIGSCHMIDT 72
HOFF, VAN'T 242
HOFMANN, A. W. VON 98
HOFMANN, F. 306
HOFMANN, K. A. 92
HOFMEISTER 242
HOLLEMAN 240
HOLLEY 201
HOOGEWERFF 232
HOOKE 199
HOOKER, A. H. 330
HOOKER, S. C. 109
HOPKINS, B. S. 244
HOPKINS, SIR F. G. 171
HOPPE-SEYLER 360
HORSFORD 208
HORSTMANN 324
HORTVET 114
HOSKINS 196
HOUBEN 300
HOWARD, H. 186
HOWARD, L. O. 162
HOWE, J. L. 216
HOWE, H. E. 349
HUDSON 26
HÜBL, VON 79
HÜBNER 286
HUMBOLDT, VON 257
HUNT, R. 110
HUNT, T. S. 248
HURD 127
HUYGHENS 104
HYATT 332

I

IPATIEFF 325
IRVINE 129
IVES 212

J

JACKSON 94
JACOBSON 278
JAEGER 131
JAFFÉ 206
JAMES 117
JANNASCH 275
JAPP 39
JOB 92
JOHNSON 88
JOHNSTON 286
JOLIOT CURIE 255
JOLIOT 78
JOLY 305
JONES, G. 14
JONES, H. C. 315
JONES, L. W. 210
JONES, W. 118
JORISSEN 315
JOULE 358
JULIUS 287
JUNGFLEISCH 355

K

KAHLBAUM, A. W. 364
KAHLBAUM, G. W. A. 98
KAHLBAUM, J. 205
KAHLENBERG 27
KAMM 340
KAYSER 75
KEHRMANN 128
KEKULÉ 250
KELVIN 177
KENNELLY 351
KERR 351
KESTNER, C. 181
KESTNER, P. 66
KEYES 175
KHARASCH 236
KILIANI 303
KIPP 64
KIPPING 228
KIRCHHOFF 71
KJELDAHL 228
KLAPROTH 335
KLASON 94
KLAUS 11
KLEIN 115
KNAPP 53
KNECHT 29
KNIETSCH 347
KNOEVERNAGEL 169
KNORR 336
KOCH 345
KÖNIG 319
KOENIGS 112
KÖRNER 110
KOHLER 310
KOHLRAUSCH 287
KOLBE 270
KOMMPPA 209
KONOWALOW 81
KÖPP 303
KOPPERS 323
KOSSEL, A. 259
KOSSEL, W. 4
KOSTANECKI 106
KRAEMER 152
KRAUS 227
KRAUT 272
KREMANN 224
KREMERS 54
KRIES, VON 279
KRÜSS 348
KÜSTER, F. W. A. 101
KÜSTER, W. 265
KUHARA 332
KUHLMANN 142
KURBATOW 215

L

LADENBURG 183
LAMB 56
LAMBERT 238
LAMY 196
LANDOLT 339
LANDSTEINER 165
LANGMUIR 31
LASSAIGNE 265
LASSAR-COHN 249
LAUE, VON 282
LAURENT 318
LAUTH 270
LAVOISIER 238
LE BEL 21
LE BLANC, M. 146
LE BLANC, N. 340
LECAT 138
LE CHATELIER 281
LEEUWENHOCK, VAN 297
LEFFMANN 252
LEHMANN 13
LEHNE 126
LÉMERY 321
LENARD 158
LEPSIUS 34
LEUCHS 238
LEVENE 56
LEWIS, G. N. 296
LEWIS, W. K. 233
LEWIS, W. L. 149
LEWKOWITSCH 247
LIEBEN 337
LIEBERMANN 54
LIEBIG 132
LIESCHE 275
LIESEGANG 305
LIMPRICHT 111
LIND 166
LINDE, VON 162
LINDEMANN 6
LIPMAN 322
LIPPICH 277
LIPPMANN, E. 267
LIPPMANN, E. O. VON 9
LIPPMANN, G. 228
LISTER 95
LITTLE 349
LOBRY DE BRUYN 1
LOCKYER 137
LOEB 97
LOEVENHART 363
LÖWIG 76
LORENTZ 199
LORENZ, H. 83
LORENZ, R. 103
LOWE 232
LOWRY 299
LUBS 354
LUCIUS 105
LUCKIESH 257
LUDWIG 19
LÜPPO-CRAMER 64
LUMIÈRE, A. 292
LUMIÈRE, L. 278
LUNGE 258
LUSK 46
LYMAN 327

M

MACLEOD 249
MABERRY 13
MAGNUS 122
MAILHE 321
MALLET 283
MALLINCKRODT 21
MAQUENNE 336
MARCKWALD 339
MARGOSCHES 120
MARGGRAF 62
MARIGNAC 114
MARKOWNIKOW 356
MARTIUS, VON 19
MASCARELLI 281
MATHEWS 288
MATIGNON 3
MAXWELL 164
MCCOLLUM 62
MCCOY 180
MCILHINEY 282
MCLEOD 50
MCPHERSON 183
MEES 146
MEISENHEIMER 165
MELDOLA 200
MENDEL 36
MENDELÉEFF 38
MENDENHALL, C. E. 213
MENDENHALL, W. C. 51
MENSCHUTKIN, B. N. 119
MENSCHUTKIN, N. A. 298
MESSEL 14
METZGER 242
MEYER, H. 80
MEYER, J. L. 231
MEYER, K. 272
MEYER, R. E. 201
MEYER, E. S. C. VON 237
MEYER, V. 251
MEYERHOFFER 256
MICHAEL, A. 219
MICHAELIS, K. A. A. 360
MICHAELIS, L. 16
MICHELSON 353
MICHLER 361
MIDGELY 138
MIETHE 115
MILLER, O. VON 127
MILLER, W. VON 343
MILLER, W. L. 253
MILLIKAN 81
MILLON 113
MINOT 336
MITSCHERLICH, A. 148
MITSCHERLICH, E. 7
MÖHLAU 245
MOHR 308
MOISSAN 271
MOLES 206
MOLISCH 340
MOND, A. M. 296
MOND, L. 66
MONTAGNE 239
MOORE, F. J. 160
MOORE, H. K. 3
MOORE, R. B. 126
MORGAN, J. L. R. 178
MORGAN, T. H. 268
MORLEY 29
MORTON 221
MOSANDER 253
MOSELY 327
MOUREU 109
MÜLLER 210
MULLIKEN 353
MUNROE 144
MURPHY, G. M. 152
MURPHY, W. P. 37
MUSPRATT 67
MYLIUS 147

N

NEF 165
NERNST 176
NEUBERG 210
NEWELL 261
NICHOLS, E. L. 257
NICHOLS, W. H. 9
NIEDERL 226
NIETZKI 68
NIEUWLAND 45
NILSON 147
NOBEL 294
NOELTING 159
NORRIS 20
NOYES, A. A. 256
NOYES, W. A. 310
NORTHRUP 186

O

ODDO, B. 24
ODDO, G. 161
ORCHSNER DE CONINCK 243
ORNSLAGER 268

OERSTED 226
OHM 75
OLIVIER 164
OLNEY 111
OLSEN 203
ONNES 264
ONSLOW 90
OPPENHEIM, A. 45
OPPENHEIM, F. 194
ORNDORFF 252
ORTON 21
OSAKA 27
OSBORNE 217
OSLER 193
OSTWALD, C. W. W. 148
OSTWALD, W. 245
OTT 199

P

PAAL 182
PANETH 243
PARR 21
PARSONS 82
PARTINGTON 171
PASTEUR 361
PATERNO DI SESSA 346
PATTERSON, A. M. 151
PATTERSON, T. S. 184
PAUL 44
PAULING 59
PAULY 199
PAVLOV 270
PECHMANN, VON 91
PÉLIGOT 83
PELLETIER 81
PELOUZE 44
PERATONER 170
PERKIN, F. M. 312
PERKIN, W. H., SR. 71
PERKIN, W. H., JR. 168
PERRIN 273
PETIT 275
PETRENKO-KRITSCHENKO 178
PETTENKOFER, VON 337
PFEIFFER 111
PFLÜGER 158
PICTET 193
PILOTY 120
PINNER 243
PIRIA 214
PITOT 151
PLANCK 113
PLANK 53
PLAYFAIR 141
PLOTNIKOW 338
POCKELS 45
PODBIELNIAK 72
POGGENDORFF 363
PONZIO 201
POPE, T. H. 32
POPE, SIR W. J. 90
POPP 212
POWER 63
POYNTING 252
PRAGER 132
PREGL 246
PRESCOTT 95
PRIESTLY 83
PRINGSHEIM, H. 365
PRINGSHEIM, P. 78
PROCTER 126
PROUST 269
PSCHORR 338
PULFRICH 267
PUPIN 277
PURDIE 27

Q

QUINCKE 323

R

RADZISZEWSKI 310
RAMAN 311
RAMMELSBERG 91
RAMSAY 275
RAOULT 130
RASCHIG 159
RASSOW 275
RATHKE 20
RÅY 233
RAYLEIGH 316
RÉAUMUR 59
RECHENBURG, VON 186
REDDELIEN 202
REDMAN 244
REESE 308
REFORMATSKY 91
REGNAULT 202
REICH 50
REICHENSTEIN, VON 152
REIMER, K. L. 359
REIMER, K. L. 71
REISENEGGER 209
REMSEN 41
RETGERS 293
REVERDIN 198
RICHARDS 31
RICHARDSON 116
RICHTER, J. B. 69
RICHTER, V. VON 105
RICHTMYER 285
RIDEAL 101
RIMBACH 360
RITTHAUSEN 13
ROBERTS-AUSTEN 62
ROENTGEN 86
ROGERS 341
ROOZEBOOM 297
ROSANOFF 362
ROSCOE 7
ROSE, G. 77
ROSE, H. 218
ROSE, R. E. 153
ROSENGARTEN 43
ROSENHAIN 236
ROSENHEIM 229
ROSENMUND 349
ROSENSTIEHL 186
ROSENTHALER 172
ROSSI 295
ROUX 351
ROWE, F. M. 42
ROWE, A. W. 212
ROWLAND 331
RÜHMKORFF 15
RUMFORD 85
RUNGE, C. 242
RUNGE, F. F. 39
RUTHERFORD, D. 307
RUTHERFORD, SIR E. 242

S

SABATIER 309
SACHSE 151
SACKUR 271
SADTLER 199
ST. CLAIRE-DEVILLE 70
SAKURAI 230
SANDMEYER 258
SCHAARSCHMIDT 91
SCHAUM 195
SCHEELE 353
SCHERRER 34
SCHIFF, H. 116
SCHIFF, R. 206
SCHLENK 53
SCHMIDT, J. 177
SCHMIDT, W. A. 152
SCHÖNBEIN 291
SCHÖNHERR 335
SCHOLL 273
SCHORLEMMER 273
SCHOTTEN 193
SCHRÖEDINGER 224
SCHRYVER 74
SCHULTZ 349
SCHULZE 212
SCHUSTER 255
SCHUTZENBERGER 357
SCOTT 225
SEDGWICK 363
SEEBECK 99
SEPSTRÖM 153
SEGER 360
SEMMLER 131
SEUBERT 96
SEYEWETZ 73
SHEPHERD 317
SHEPPARD 210
SHERMAN 289
SIDGWICK 128
SIEGBAHN 337
SIEMENS, F. 342
SIEMENS, E. W. 347
SIEMENS, K. W. 94
SIEMENS, W. VON 211
SILLIMAN 220
SILVERMAN 122
SIMON 364
SIMONSEN 22
SKITA 49
SKRAUP 62
SLATER 356
SLOSSON 158
SMITH, A. 254
SMITH, E. F. 143
SMITH, G. O. 53
SMITH, J. L. 351
SMITS 165
SMYTH 41
SOBRERO 285
SODDY 245
SÖRENSON 9
SOLVAY 106
SOMMERFELD 339
SOMMERFELDT 192
SORBY 130
SOUBEIRAN 144
SOXHLET 12
SPÄTH 134
SPIRO 175
SPRENGEL 241
STAEDEL 77
STÄHLER 200
STARK 105
STAS 233
STAUD 302
STAUDINGER 82
STEENBOCK 228
STEFAN 83
STEINMETZ 99
STENHOUSE 294
STIEGLITZ 146
STOBBÉ 160
STOCK 197
STOHMANN 115
STOKES 225
STOLLÉ 198
STOLZ 96
STORER 86
STORM 324
STORTENBEKER 138
STRATTON 199
STRAUBEL 167
STROMEYER 214
STROOF 98
SUDBOROUGH 315
SULLIVAN 23
SUMNER 323
SUTERMEISTER 333
SVEDBERG 242
SWAIN 5
SWAN 304
SZENT-GYÖRGI 259

T

TAKAMINE 266
TALBOT 135
TAMMANN 148
TANRET 222
TAYLOR 37
TEEPLE 4
TENNANT 334
TER MEULEN 334
THALÉN 362
THÉNARD, A. P. E. 279
THÉNARD, L. J. 124
THIELE 133
THOMPSON, G. W. 208
THOMPSON, S. P. 170
THOMPSON, W. B. 133
THOMSEN 47
THOMSON, E. 88
THOMSON, J. J. (SIR) 352
THORPE, J. F. 335
THORPE, T. E. (SIR) 342
TIEMANN 161
TIFFENEAU 311
TILDEN 227
TOEPLER 250
TOLLENS 211
TOLMAN 63
TONE 289
TRAUBE, J. 90
TRAUBE, W. 10
TRAUTZ 78
TREADWELL 36
TROOST 290
TROUTON 328
TROPSCH 280
TSCHITSCHIBABIN 87
TSCHUGAJEFF 277
TWITCHELL 57
TYNDALL 233

U

UNVERDORBEN 286
URBAIN 102
UREY 119

V

VAIL 320
VALEUR 163
VAN LAAR 192
VAN SLYKE, D. D. 88
VAN SLYKE, L. L. 6
VARENTRAPP 241
VAUBEL 330
VAUGHAN 300
VAUQUELIN 136
VENABLE 321
VIEILLE 245
VILLIGER 244
VINCENT 228
VOGEL 85
VOLHARD 155
VOLTA 50
VONGERICHTEN 59-A
VORLÄNDER 162
VORTMANN 60

W

WAAGE 180
WAALS, VAN DER 327
WACKENRODER 67
WAGNER 333
WAGNER-JAUREGG, VON 66
WALDEN 207
WALKER, J. (SIR) 96
WALKER, W. H. 97
WALLACH 86
WALTON 72

WARBURG, E. G. 68
WARBURG, O. H. 281
WASHBURN 130
WASHINGTON 15
WATERMAN 118
WATTS 20
WEDEKIND 31
WEGSCHEIDER 281
WEHNELT 94
WEIDLEIN 195
WEINBURG, VON 223
WELCH 98
WELDON 304
WELSBACH, VON 244
WERNER 346
WESSON 14
WESTINGHOUSE 279
WESTON 129
WEYL 8
WHERRY 253
WHIPPLE, G. C. 61
WHIPPLE, G. H. 240
WHITAKER 350
WHITE, A. H. 119
WHITE, W. P. 54
WHITMORE 274
WHITMAN 334
WHITNEY 234
WICHELHAUS 8
WIEDEMANN, E. E. G. 213
WIEDEMANN, G. H. 275
WIELAND 155
WIEN 13
WIENER 166
WILCKE 249
WILEY 291
WILL, H. 342
WILL, C. W. 102
WILLIAMS 265
WILLIAMSON 121
WILLGERODT 306
WILLSTÄTTER 225
WILSON, C. T. R. 45
WILSON, J. A. 228
WILSON, R. E. 78
WINDAUS 359
WINKLER 360
WISLICENUS, J. 175
WISLICENUS, W. 23
WITT 90
WOHL 276
WÖHLER 212
WOLFF 270
WOLLASTON 218
WOOD 122
WOODHOUSE 321
WORDEN 107
WURTZ 330

Y

YOUNG 363

Z

ZEEMAN 145
ZEISEL 100
ZELINSKY 25
ZINCKE 139
ZININ 237
ZSIGMONDY 91

HEINRICH WIELAND*

AT THE establishment of the Nobel Foundation, that remarkable trust fund which produces the five Nobel Prizes, the Swedish Academy of Science was entrusted with the responsibility of naming each year "the person who shall have made the most important chemical discovery or improvement." Occasionally, heated discussions and even criticisms have been provoked by the announcements of the awards in some of the five sections, but from the beginning (1901) the chemical awards have, without exception, been universally applauded as well-deserved recognition of meritorious services. Heinrich Wieland, master organic chemist, was enrolled in this company of the truly great in 1928.

Wieland (b. 1877) obtained his chemical training at Berlin, Stuttgart, and principally Munich, where he received his doctorate in 1901. His thesis, prepared under the direction of Thiele, dealt with their unsuccessful attempts to prepare asymmetric substituted allenes. He began his teaching career in Munich in 1904, served at the Technical High School there until 1921, when he went to the University of Freiburg i. Br. After only four years, he was called back to Munich as head of the chemical department of the University of Munich, where he is proving a worthy occupant of the chair of Liebig, von Baeyer, and Willstätter.

Of the many fields of organic chemistry that he has tilled successfully only the more important need be mentioned here. His early studies dealt with fulminic acid, nitrile oxides, hydrazines, and aliphatic azo compounds. In the course of these studies, he discovered the radicals of di- and quadrivalent nitrogen. In 1911 he began his researches on hydrogenation and dehydrogenation, important not only in themselves, but because they led to a new theory of biologic oxidation. First-class studies of alkaloids—morphine, lobelia, strychnos—stand to his credit. More than twenty years of work have gone into his investigations of the constitution of bile acids and his studies of the chemistry of toad venom. Undergraduates know him best as the revisor, or more properly, the rewriter of Gattermann's classic text "Laboratory Methods of Organic Chemistry."

DIPLOMA AWARDED ON DECEMBER 30, 1928, TO HEINRICH WIELAND BY THE SWEDISH ACADEMY OF SCIENCES ON THE OCCASION OF HIS RECEIPT OF THE NOBEL PRIZE FOR CHEMISTRY

(Contributed by Ralph E. Oesper, University of Cincinnati)

* See frontispiece.

W. O. Brooks
A. T. Burtsell
R. K. Carleton
Tenney L. Davis
J. Howard Graham
B. Clifford Hendricks
J. W. Howard

ABSTRACTS

R. A. Baker, *Abstract Editor*

D. C. Lichtenwalner
Greta Oppe

C. M. Pruitt
Leopold Scheflan
A. A. Vernon
E. D. Walter
Mary Elvira Weeks
Sidney Weinhouse
G. H. Woollett

KEEPING UP WITH CHEMISTRY

Recent advances in our knowledge of the vitamins. H. L. Mason. *Sch. Sci. & Math.*, **37**, 264–72 (Mar., 1937).—Complete structural details of five of the vitamins are known, four of them having been prepared in the laboratory by chemical means. The task of isolating them has been beset with many difficulties, vitamin B, the first one to be discovered, offering a good example. One ton of rice polishings yielded five g. of pure crystalline vitamin B. This is about twenty-five per cent. of the vitamin that is present. R. R. Williams isolated vitamin B, determined its structure, and finally announced its synthesis in August, 1936. It plays a part in the utilization of carbohydrate. Its deficiency causes polyneuritis or beriberi.

Carotene of carrots, corn, butter, and green leaves possesses some vitamin A activity. The vitamin A that is found in cod-liver oil, however, is not carotene. Vitamin A has been isolated from cod-liver oil in a sufficiently pure state to determine its chemical nature. It is a highly unsaturated alcohol containing eleven double bonds in its chemical structure. Presumably, the liver can split the carotene molecule between the ninth and the tenth carbon atoms, with the placement of the alcohol group on the ninth carbon atom, when vitamin A results. This explains the vitamin A activity of carotene. Alpha- and beta-carotene are recognized. Alpha can yield only one molecule of vitamin A, while beta can yield two molecules of vitamin A. Oxidation and light destroy vitamin A. A good deal of publicity has been given to the idea that vitamin A in sufficient quantity confers protection against the common cold. A recent study of two hundred students indicated that an intake of five thousand units (when three thousand units would be used ordinarily) reduced the average duration of colds in this group, but the number of colds was not reduced significantly. Vitamin A is definitely not to be considered as a cure for colds, or as effective in the treatment of them. A deficiency of vitamin A results in a deficiency of visual purple and consequent inability to see at night. Antimony chloride added to a solution of vitamin A in chloroform produces a blue color. A better means of estimation of vitamin A strength is the intensity of absorption at a particular wave-length in ultra-violet light.

Vitamin C was first isolated in 1928, but it remained unrecognized as a vitamin for four years. When its identity was recognized, there was a rush to synthesize it and success came to a group of English workers. Glucose is reduced to *d*-sorbitol; this is oxidized by *B. xylinum* to *l*-sorbose; this treated with HNO_3 gives 2-keto-*l*-gluconic acid which in turn loses the elements of water to become *l*-ascorbic acid, $C_6H_8O_6$, OC.COH:-COH.CH.CHOH.CH_2OH, or vitamin C. Vitamin C has the properties of an acid and has been named with reference to its ability to prevent and to cure scurvy. It is a powerful reducing agent, instantly reducing gold chloride to a sol of metallic gold. Titration with dichloro-indophenol is used for the estimation of vitamin C in foods.

In considering vitamin D, the formation of antirachitic substances by the irradiation of ergosterol and of various foods is commonplace nowadays. Rather recently it has become evident that the viosterol produced by the irradiation of ergosterol is not the same as the vitamin D of cod-liver oil. It appears that cod-liver oil is about three times as effective as viosterol. At one time it was thought that cholesterol itself was converted to vitamin D by ultra-violet light. It is probable that the vitamin D produced by the action of sunlight upon the skin is derived ultimately from the animal sterol, cholesterol, and not from ergosterol, which is a plant sterol. Formulas are given to show the structural relations among ergosterol, viosterol (calciferol) and cholesterol. Vitamin D is toxic in large doses.

As a result of the study of vitamin B, there has been found evidence for another vitamin B_2 or G. It is probably a complex of vitamins called B_3, B_4, B_5, and B_6. One has been isolated and identified as lactoflavin, a complex nitrogen containing a compound with a carbohydrate side chain which is derived from the five-carbon sugar *d*-ribose.

Vitamin E has only recently been isolated. Its empirical formula is $C_{29}H_{50}O_2$, and it is an alcohol. It has been named "alpha-tocopherol." It is essential for the maintenance of the reproductive function in both males and females. There are other less known vitamins which cannot be described in chemical terms, but only in terms of pathologic conditions.

J. H. G.

On high pressure drives. Anon. *Ind. Bull. of Arthur D. Little, Inc.*, **121**, 2–3 (Feb., 1937).—To fulfil the lubricating requirements of hypoid and highly stressed spiral bevel gears, special lubricants have been developed and have come to be known as extreme-pressure (E. P.) or hypoid lubricants. There are three broad classifications of these lubricants, namely, lead base, sulfur base, or chlorine base. Combinations have also been found effective. G. O.

New Koppers phenolate process. Anon. *Chem. Industries*, **10**, 151 (Feb., 1937).—"The first plant in the east which will purify refinery gas by the new Koppers phenolate process, is to be erected soon for Atlantic Refining at its Philadelphia refinery, by the Engineering and Construction Division of Koppers. A similar plant, the first to use this patented process, was erected by Koppers at El Segundo, near Los Angeles, California, for Standard Oil of California, and was put into operation August 6, 1936.

"By this process the gas is prepared for treatment in a polymerization unit for production of liquid hydrocarbons, it being purified to the extent of 95 to 99.8 per cent.

"Plant to be built for Atlantic Refining will be able to recover the hydrogen sulfide from 22,000,000 cubic feet a day of refinery still gases at 225 lbs. pressure. The hydrogen sulfide may be converted to sulfuric acid, and the purified still gas will be further processed by polymerization.

"The purification system consists of an absorption stage and an actification stage, through which the phenolate solution is circulated continuously. This solution has an extremely high carrying capacity for hydrogen sulfide, amounting to 2000 to 4000 grains per gallon. As a result it is necessary to circulate only five to ten gallons of solution per thousand cubic feet of sour gas. This very low circulation rate is one of the reasons for the low operating expense and the simplicity of equipment required in comparison to other liquid purification processes."

A. T. B.

Butyl alcohol and acetone from molasses. Anon. *Chem. Industries*, **10**, 152 (Feb., 1937).—"Details of the method for the production of butanol and acetone from molasses, developed by Rafael Arroyo, of Puerto Rico, are given in the English Patent specification 453,524 of 1935. A new organism has been isolated from the nodes of Kassoer cane, and is now called *Bacillus tetryl*. It is characterized by its ability to ferment invert sugar with the formation of butanol and of acetone with a low proportion of ethyl alcohol. It is incapable of fermenting sucrose, and is acclimatable to densities in excess of 12° Brix." A. T. B.

Vacuum concrete. ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **122**, 2 (Mar., 1937).—This is a new method of making concrete and is considered by some authorities as possibly the most significant recent development in the building field. The poured concrete is covered with a mat and the air sucked out, as well as the excess water. Atmospheric pressure compacts the slab, and a quicker, denser, and, it is said, a stronger structure is made. It is possible to walk on such concrete twenty minutes after pouring without leaving footmarks. Vacuum concrete is said to reduce road costs as much as $5000 a mile and cut to a third the time of detours. The potential importance of vacuum concrete in low-cost housing suggests trial in Federal projects.
G. O.

"Nitrogen for growth." ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **122**, 2–3 (Mar., 1937).—With the fixation of nitrogen man's status has changed. No longer is he dependent upon the bounty of nature. With the unlimited supply of ammonia and nitrates which he can make from the atmosphere whenever he wishes, he has a means of procuring all the food which he may wish. The fixation of nitrogen can make a nation independent of other nations for its food supply, munitions of war, military and civil explosives, etc. Available nitrogen determines the growth of the plant and man. While "nitrogen for growth" is a true saying for the garden, it is also profoundly true for the race. By its fixed nitrogen the race lives; by its fixed nitrogen, it grows in body and mind. G. O.

Ah, Watson! ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **122**, 4 (Mar., 1937).—Fingerprints of chemical substances are being collected and classified by research chemists of the Dow Chemical Company; but in place of carbon dust or fluorescent dyes X-rays are used to make diffraction patterns of chemicals. Exposure to X-rays, of as little as one cubic millimeter of material gives a configuration picture of lines varying in intensity and spacing. The material is not destroyed in the tests. Unknowns, even with a composite of various patterns, are compared with the prints for rapid identification. A calibrated scale against which all pictures are read gives interplanar distances in Ångström units; the files or films are kept in a record book according to the three most intense lines showing, into group, sub-group, and position of the sub-group. G. O.

Rayon. ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **122**, 1–2 (Mar., 1937).—Rayon has to its credit a number of active new developments including improved tensile strength, pigmentation, and rayon staple. Increase in tensile strength has been slow, advancing, however, with a better understanding of cellulose molecules. By stretch spinning these chains are drawn into stronger patterns. Ordinary rayon is strong enough for general textile purposes, but elasticity is what is badly needed. "Cordura" and "Tenasco" are making themselves known on the industrial market. The glossy brilliance of rayon, advantageous for many purposes, has been a limiting factor for other purposes. This is no longer true, since titanium oxide, a dead white pigment, is added to make a dull rayon. Staple rayon, an offshoot of filament rayon, is really a new textile fiber. It is produced from a spinneret with over one thousand three hundred holes, in a "tow" of great size and cut to any desired size. The cut or staple fiber is then spun into yarn. Staple yarn is usually spun in mixtures with cotton, silk, mohair, rabbit hair, or worsted for use in underwear, dress goods, suitings, and, recently, in pile upholstery fabrics. It is soft and flexible. It sells now for twenty-eight cents a pound. G. O.

The compounds of the inert gases. R. S. BRADLEY. *Science Progress*, **31**, 282–6 (Oct., 1936).—It is well known that Ramsay and his co-workers made repeated but unsuccessful attempts to combine the inert gases with other elements. The valence was considered to be zero and since the new elements fitted conveniently into Group 0 of the periodic table, they were expected to be chemically uninteresting. The inert gases do not actually have the maximum number of electrons in their outer shells. The electronic configurations are .

He 2; Ne 2, 8; A 2, 8, 8; Kr 2, 8, 18, 8; X 2, 8, 18, 18, 8; Rn 2, 8, 18, 32, 18, 8

Since the maximum number of electrons in a quantum group n is $2n^2$, it follows that the third and higher groups in A, Kr, X, and Rn are capable of expansion. The inert gases might therefore be expected to act as acceptors of electrons.

Examples of the first type of coördination, wherein the inert gas atom accepts electrons, were studied soon after the discovery of the inert gases by de Forcrand, who found that when a mixture of the inert gas and water was cooled under pressure hydrates appeared. When the structures of these compounds are studied, it is shown that they fall into line with coördination compounds of the cobalt-ammine type such as $[Co(NH_3)_6]Cl_3$.

The formation of hydrates receives additional support from the study of the solution of the inert gases in water. It has been shown that in all cases the solubility decreases with temperature. The heats of solution range from approximately zero for He to a few thousand calories for Rn, but the log of the solubility does not vary perfectly linearly with the inverse absolute temperature, and the heat of solution varies considerably with temperature. It is difficult to assess the energy changes involved.

It has been found further that compounds form between A and BF_2 under high pressures and low temperatures, in the formula A $(BF_3)n$, where $n = 1, 2, 3, 6, 8$, and 16. Helium does not form compounds of this type. A halide of mercury has been produced for which the formula $HgHe_{10}$ has been proposed. Subsequent analysis has resulted in a modification of the proposed formula to HgHe or $HgHe_2$. It is interesting to note that traces are undoubtedly formed whenever helium is used in a system containing mercury.

The preparation of several other helides has been reported. A glowing tungsten tube put into helium in a discharge tube resulted in the production of a solid black deposit which could be collected and weighed. The formula was determined as WHe. Excited helium atoms can also be made to combine with the vapor of mercury, iodine, sulfur, and phosphorus, giving compounds condensable in liquid air, with rapid disappearance of the He, the pressure of which fell from 0.1–0.2 mm. to 0.005 mm. When the condensate was warmed, a sudden evolution of helium occurred at temperatures far below the freezing points of the vapors, *viz.*, for mercury and iodine at −70°C., and for sulfur and phosphorus at −125°C., so that it is improbable that the helium was merely occluded.

The possibility arises that other inert gases may form compounds after excitation but up to the present the evidence is negative. It has been claimed that a chloride of krypton was produced by passing a discharge through krypton and chlorine and condensing in liquid air, but later work showed that NO had been formed by traces of air and HCl which had been formed by the grease. The compound between NO and HCl, which is red, was at first thought to be krypton chloride. R. K. C.

The nutritive value of papaya. C. D. MILLER AND R. C. ROBBINS. *Biochem. J.*, **31**, 1–11 (Jan., 1937).—Papayas grown in Hawaii have been analyzed for organic nutrients, Ca, P, Fe, Cl, and acid-base balance. Papaya compares favorably with oranges as a source of Ca, basic ash, and ascorbic acid. The vitamin C content increases with the ripeness of the fruit.

Average papaya is estimated to contain per 100 g. of edible material, 2500 international units of vitamin A, 8 international units of vitamin B_1, 70 mg. of ascorbic acid, and 33 Bourquin-Sherman units of vitamin B_2. E. D. W.

Industrial uses of titanium oxide. G. F. NEW. *Chem. Industries*, **10**, 157–9 (Feb., 1937).—"In the products of a widespread range of industries there is a demand for whiteness and a clean appearance such as, for instance, paints, rubber, plastics, paper, leather, etc. This demand for whiteness is probably based on a fashion which, however, is not transient, but appears to remain constant and strong from year to year. Whiteness can be obtained in two ways; first, by the bleaching out or destruction by chemical or other means of the coloring matters inherent in the basic substance; second, by the addition of intense whitening materials which will obliterate the residual color in the basic substance and impart their own brilliance and purity of appearance.

"The days when white lead was the only white pigment in common use have passed, and for decades now new white pigments have been produced, each more intense in its action than the last. The latest in this series is titanium dioxide and it surpasses, in degree of whitening action or tinting strength, all its predecessors. In oil, for instance, it has a tinting strength of approximately eleven times that of white lead. That is to say, if two greys are made up to match from the same amounts of black and in the one case white lead, and in the other titanium dioxide, the weight of titanium dioxide needed will be only one-eleventh that of the white lead. The reason for this powerful action is based on two characteristics of the new pigment, (1) its extraordinarily high refractive index, and (2) its very fine particle size. The higher refractive index indicates that an unusually high degree of bending is induced when a ray of light passes from air into the solid, as well as an unusually high degree of surface reflection from the particle back into the air.

"In a layer of pigment particles, this transition from air to

solid occurs, even in a thin layer, many times. The result of the solid having a high refractive index is that the scattering of the incident radiation is high and that the contrast in a background is obliterated in a thinner layer than would be the case if the refractive index were lower. In other words, the pigment of high refractive index has exceptional obliterating or covering power. The finer the particle size, moreover, the more frequently does the incident light meet an interface between solid and air and, therefore, more scattering is induced in a layer of a given thickness, again resulting in an intensification of obliterating power. The same argument applies if air is displaced by oils as in a paint or rubber or plastic or other material." A. T. B.

HISTORICAL AND BIOGRAPHICAL

Twentieth anniversary of the Chemical Research Institute at Warsaw. ANON. *Nature*, **139,** 519 (Mar. 20, 1937).—The Chemical Research Institute of Warsaw was founded by President Ignacy Moscicki. In 1916 he founded the Metan Company in Lwów to carry out chemical research for industry. In 1922 the shareholders of this company transformed it into the Chemical Research Institute Association, which expends all revenue and earnings on new research work, which is chiefly concerned with petroleum, natural gas, sulfuric acid, aluminum, the analysis and standardization of coal, metallurgical coke, and rubber. In 1925 the Institute was transferred to Warsaw. The twentieth anniversary of its founding was observed in the Warsaw Polytechnic on December 9. President Moscicki was present. M. E. W.

Fifty years of progress. Chemical reminiscences. H. O. CHUTE. *Chem. Industries*, **10,** 30–2 (Jan., 1937).—The author has written here some very interesting reminiscences out of an experience that reaches from the forests of British Columbia to the mines of Mexico and a practical working knowledge of almost every branch of the industrial activities of American chemistry. His closing words are, "Much we call progress is at best mere readaptation of old principles of chemistry and engineering to new problems. At worst it is only a crab-like movement in a new direction rather than steps forward." A. T. B.

Twenty-fifth anniversary of Laue's diagrams. A. E. H. TUTTON. *Nature*, **139,** 517–9 (Mar. 20, 1937).—*Current Science*, a monthly scientific journal published at Bangalore, India, has devoted a special issue to the twenty-fifth anniversary of Max von Laue's discovery of the diffraction of X-rays by crystals. It contains articles by Professor von Laue, Sir William and Professor W. L. Bragg, Professors P. P. Ewald, M. Siegbahn, A. Sommerfeld, L. Pauling, and C. G. Darwin, Dr. S. Rama Swamy, and others, an introduction by Sir C. V. Raman, and a frontispiece portrait of Professor von Laue.

"Professor von Laue throws a little further light on the circumstances in which in February 1912 his discovery was made . . . P. P. Ewald went to him for advice . . . During the discussion, the fact became prominent that a crystal is essentially a three-dimensioned lattice, and the question suddenly dawned in Laue's mind, as to what would happen if such a lattice were approached by a radiation of which the wave-length was short compared with the lattice-constant (unit cell dimension). The analogy of light waves and gratings suggested that diffraction must ensue. Remembering that Wien and Sommerfeld had only recently found Röntgen rays to possess a wave-length of the order 10^{-9} cm., and that the lattice constant must be somewhere about 10^{-8} cm., Laue came at once to the inspiring conclusion that the conditions for diffraction were highly favourable. Just at that moment entered W. Friedrich, Sommerfeld's assistant, and . . . at once expressed a wish to put the matter to an immediate experimental test. Now Laue was obviously accepting Sommerfeld's view that the X-rays were a wave-motion . . . Friedrich obtained the help of a specially able experimental colleague, P. Knipping." . . . The results obtained with copper sulfate were promising, but inconclusive. "But on substituting a crystal of zinc blende, as advised by Professor von Groth, . . . the now well known excellent pattern of cubically symmetrically arranged spots was obtained." M. E. W.

THE PHILOSOPHY OF EDUCATION

The Providence experiment in junior engineers' development. STAFF REPORT. *Chem. & Met. Eng.*, **44,** 128–30 (Mar., 1937).—Filling the gap between college graduation and the time when he becomes established in his profession is one of the important problems facing the young chemical engineer. In the past it has been left to the engineer to formulate his own program of development. To meet this need the Providence Engineering Society has organized an active group program. This program includes a general monthly meeting attended by seventy-five to one hundred junior engineers, five self-conducted discussion groups meeting monthly or bi-weekly and several lesser activities. The organization is open to men in any of the engineering fields

The chief aims of the group are (1) to afford an opportunity for acquaintance with other young engineers, with leading professional and business men, and with the business and economic life of the community; (2) to provide incentives for study and personal development through the medium of group activity; (3) to encourage practice in self expression and clear thinking. Since these aims are nothing temporary nor productive of a fad it is felt this movement should always find a place in professional development. J. W. H.

GENERAL

Scientific worthies and events commemorated on postage stamps. J. G. PILKINGTON. *Nature*, **139,** 331–2 (Feb. 20, 1937).—Ecuador celebrated the centenary of Darwin's visit on September 16, 1835, by a special issue of postage stamps. France has similarly honored Louis Pasteur, P. E. M. Berthelot. Pilatre de Rozier, and Louis Blériot. "A recent issue also shows Pasteur at work." Last year Germany issued stamps bearing portraits of Otto von Guericke, Daimler, and Benz. There are Italian stamps bearing portraits of Volta and Galvani. The U. S. S. R. has a Mendeléeff issue and Yugoslavia, a Nikola Tesla stamp. Austria has recently issued a set showing six inventors. M. E. W.

Natural philosophy. ANON. *Ind. Bull. of Arthur D. Little, Inc.*, **121,** 1–2 (Feb., 1937).—Recognition is growing that the history of science is one of the "cultural disciplines". Courses in the subject are given at our important engineering schools and at several of the older universities which have long been strongholds of classicism. Scholarly books have begun to appear and popular books which unroll the drama of man's quest for truth. Research is a high adventure. The world will always be a different place because pottery, gunpowder, and printing were invented, because America, X-rays, antitoxins, and the electron valve have been discovered. These things affect man's outlook, man's thoughts, man's way of living, and man himself. The beginnings of chemistry, obscured in the mists of prehistory, are nevertheless the beginnings of civilization. The history of inventions is the history of the epochs of mankind. G. O.

RECENT BOOKS

LABORATORY METHODS OF ORGANIC CHEMISTRY. *L. Gattermann.* Revised by *Heinrich Wieland.* Translated from the twenty-fourth German edition by *W. McCartney.* The Macmillan Company, New York City, 1937. xvi + 435 pp. 59 figs. 14.5 × 21.5 cm. $4.50.

The present edition of this excellent laboratory manual retains the characteristics which have marked it throughout a long and honorable history. A book which has passed through twenty-four editions during a span of over forty years has small need of an appraisal, and an extended review is perhaps supererogatory.

The noteworthy features of "Gattermann" are familiar, *viz.*, considerable diversity of experiments, and supporting sections devoted to explanation and extension. As is stated in the older preface (page vii), and as is obvious from the nature of some of the discussions, the manual is designed especially for the use of students who are already acquainted with the essentials of organic chemistry, though by a careful selection of experiments and of appropriate explanatory material the book can, of course, be used profitably by beginners.

The principal sections deal with general operations (pages 1 to 42), organic analytical methods (pages 43 to 87), preparations and discussions (pages 88 to 417), and hints on the use of the literature (pages 419 to 422).

The preliminary section on general operations is suitably brief and elementary, which is much to be preferred to an elaborate and detailed account of such matters at this point. It would seem proper, however, to advise the student of the hazards involved in the use of a vacuum desiccator containing concentrated sulfuric acid. The process of fractional distillation is merely outlined, nor is there at any later point any exercise in which this important process is adequately illustrated or described. There is no mention of corrected thermometric readings anywhere in the book.

The most striking change in the new edition is the analytical section, which has been placed on a "meso-analytical" (semimicro) basis. This is to be welcomed, and is representative of the present tendency among organic chemists. Most of the methods described are adaptations of Pregl's procedures; their development is credited to F. Hölscher. The procedures are well presented, with the limits of accuracy stated. Nitrogen is determined by the Dumas method; the Kjeldahl method is not mentioned. In the determination of carbon and hydrogen lead dioxide is replaced (in the tube-filling) by reduced copper; this substitution probably makes less serious the omission of any mention of a blank analysis. Halogens are determined by the Carius method, and as an alternative an adaptation of the Pregl decomposition is described, chlorine and bromine being titrated with the aid of an adsorption indicator, and iodine by the iodide-iodate method. The Carius and Pregl methods are used for sulfur. Alkoxyl groups are determined by the Vieböck and Brecher method. There are described also the determinations of acetyl and benzoyl groups. The determination of molecular weights by the method of Rast, and the macro-determination of active hydrogen by use of methyl magnesium iodide are retained from the previous edition.

The experiments and the accompanying discussions (three hundred twenty-nine pages) cover a wide range with respect both to subject matter and degree of difficulty. The selection of experiments reflects the extensive experience and wide interests of the authors. Almost all the important reactions and preparative methods, and many of secondary importance, are illustrated by one or more experiments, and others are recommended to the student in the extensions. There appears to be no mention of the Ullmann reaction.

In this edition the manual presents an experiment on chromatographic adsorption, in which there are revealed to the student some of the well-concealed beauties dormant in the leaves of the despised, albeit energizing, spinach. There is also an example of ozonolysis (adipic aldehyde from cyclohexene). A few experiments in the preceding edition have been deleted. Except for these changes, and several modifications of procedures, the experiments are about the same as those in the previous edition.

The experimental procedures are well described and, in general, are wisely chosen. In some cases older methods are retained (as for preparation of phenylhydroxylamine, quinoline, and furfural) although better methods are now available (*e.g.*, in "Organic Syntheses"). The recovery of alcohol following fermentation appears to represent a singularly ineffective fractionation, for after three distillations through "an efficient column (Raschig rings)" the alcohol is of less than thirty per cent. concentration. In the experiments on the preparation and use of diazomethane and on isolation of nicotine no mention is made of the toxicity of these compounds. The ozonization experiment includes no description of the ozonizer, though in many laboratories it would be necessary to build this apparatus.

The "theoretical" sections are valuable as a means of broadening the student's viewpoint and of providing him with essential information. These sections make "Gattermann" the most explicitly informative student manual known to the reviewer. On the other hand, it seems that some of the experiments and explanatory material deal with matters of rather restricted interest. In certain of the discussions the student is led somewhat far afield among reactions which are interesting but exceptional and of perhaps doubtful appropriateness in a student laboratory manual. This is the case with part of the material on nitromethane and derived compounds, phenylhydroxylamine, dehydracetic acid and related pyrones, and phenyldiazonium perbromide, and with the four pages devoted to ethyldiazoacetate. In view of the degree of familiarity with chemistry assumed elsewhere in the book it seems unnecessary to include so elementary an account of the application of the mass-action principle to the process of esterification, addressed apparently to students who have not yet heard of reversible reactions.

The discussion which accompanies the preparation of ethyl acetoacetate gives only the Scheibler explanation of the reaction, ignoring the protests of Adickes and the explanation offered by McElvain [*J. Am. Chem. Soc.*, **56**, 1173 (1934)]. The quinoid structure is assigned to "tribromophenolbromide," with no mention of the contrary findings of Lauer [*ibid.*, **48**, 424 (1926)]. In the account of the Grignard reaction there appears the unqualified statement that aryl halides yield Grignard compounds, without calling attention to the unsatisfactory behavior of chlorides [Gilman and St. John, *Rec. trav. chim.*, **49**, 717 (1930)]. The Grignard synthesis is called a "synthesizing hydrogenation," an artificial designation which places undue emphasis on the "hydrogenation" and too little on the alkylation. Attention is not directed to the alcoholate character of the addition compound, though recognition of this fact is helpful to students. On the whole, the account of the Grignard reaction is perhaps the least satisfactory discussion of an important matter in the book. The three-page explanatory section which follows the experiment on isolation of hemin from blood seems not wholly in place in a laboratory manual. This experiment, that on chromatographic analysis, and the final experiment on the bile acids and cholesterol, bring the preparative part to an impressive conclusion, and emphasize the fact that this manual can be used to advantage by students considerably beyond the undergraduate stage.

The short section on the use of the organic chemical literature deals almost exclusively (and very sketchily) with the German formula indexes and with the Beilstein "Handbuch". The terminal date of the third edition of Beilstein is given as July 1, 1899, and the number of volumes probably to be required for the fourth edition is optimistically put at twenty-five. The only

journal mentioned is *Chemisches Zentralblatt*. The wholly German character of this section is perhaps not surprising in the original, but it is to be regretted that the English edition fails to commend to the student such valuable works as *Chemical Abstracts*, *British Chemical Abstracts* and "Organic Syntheses". The discussion of the literature is followed by a list of supplementary preparations for which directions are to be sought in original papers.

The book is excellently printed, with few mistakes; ten were discovered in the reading of perhaps eighty per cent. of the text. The translation in some places retains the unmistakable flavor of the German original. The line drawings are clear, but would win no very high grade from a teacher of mechanical drawing.

It is hoped that the foregoing critical account will not misrepresent the high opinion the reviewer holds of this laboratory manual as a guide for students of all stages of advancement. The careful examination of this new edition was a profitable and pleasant experience. If "Gattermann" needs a recommendation it is heartily given.

E. C. WAGNER

UNIVERSITY OF PENNSYLVANIA
PHILADELPHIA, PENNSYLVANIA

SPECIFIC TESTS FOR USE IN THE "QUAL." COURSE. *Wayne E. White*, Research Fellow, University of Kansas, Lawrence, Kansas. Private Publication, 1937. 14 pp. 15 × 22.5 cm. $0.25.

A pamphlet of a few pages devoted to instructions to the student for carrying out specific tests for ions in *original* solutions of unknowns encountered in the usual course of qualitative analysis. The ions considered for such tests are as follows: bismuthous, ferric, ferrous, barium, stannous, stannic, manganous, nickelous, cobaltous, aluminium, chromate, and zinc ions. Directions are also given for the preparation of the organic reagent solutions. Sets of these reagents may be obtained from the author.

WARREN C. JOHNSON

UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS

PHYSICAL CHEMISTRY. *F. Tanchoco*, A.B., Ph.C., Ll.B., Professor of Chemistry, Manila College of Pharmacy. Benipayo Press, Manila, P. I., 1936. viii + 173 pp. 21 × 27 cm.

"This book was written for beginners and especially for the freshman class of the Manila College of Pharmacy, by one who possesses only a working knowledge of English." This quotation from the foreword furnishes the key to an understanding of the book. The title is somewhat of a misnomer. "Introductory Chemistry" would be more descriptive, since "the book is intended to serve as constant reference material during the subsequent studies of Descriptive Inorganic Chemistry, Organic Chemistry, and Analysis." It is somewhat analogous to the texts, etc., used in various pandemic courses in this country. As in mimeographed texts, only one side of each sheet is printed, the other side being used for lecture notes and sketches of which there are none.

Subjects considered are Matter and Energy, Gravitation, Hydrostatics and Hydrodynamics, Heat, States of Matter, Solutions, Colloids, Cohesion and Adhesion, Affinity, Atoms and Molecules, Valence, Atomic and Molecular Weights, Thermochemistry, Electricity and Magnetism, Ionic Theory, Electrical Nature of the Atom, Theories of Atomic Structure, Types of Compounds, X-rays, Radioactivity and Nomenclature. Three appendices are included: a table of water-vapor pressures, the common elements grouped by families with their valences, and a table of atomic weights.

The book is devoid of mathematics. The author's selection of subjects for an introductory course is open to criticism, although their interest-arousing value is unquestioned. However, there is at present no general agreement on the desirable content of such a course. There are numerous examples of bad spelling —probably typographical errors—and of word usage. The latter is quite pardonable in view of the author's own statement. Inaccuracies in statement are not numerous. Perhaps the most important are found on page 46. Percentage concentration is grams solute per one hundred grams of solution. The abuse of this term is all too frequent in the literature. The author discusses this and other usages, but fails to emphasize the correct meaning. Molar and normal solutions are mols or equivalents per liter of solution, instead of per liter of solvent as given.

The book presents numerous instances of beautifully clear presentation of abstruse ideas. Even a novice can grasp them. For this alone it merits examination by those teaching similar courses. Professor Tanchoco is to be commended also for his insistence on the speculative nature of many of the new concepts. The following is typical. "However, this theory is far from being perfect as it is true only of a fictitious ideal solution or of infinite dilution, and it is particularly disconcerting that the theory fails when it is most needed."

In conclusion it may be stated that this work meets the need it was designed to fill and can probably furnish ideas on presentation to others.

MALCOLM M. HARING

UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

ELEMENTARY PHYSICAL CHEMISTRY. *Hugh S. Taylor*, *David B. Jones* Professor of Chemistry, Princeton University, and *H. Austin Taylor*, Assistant Professor of Physical Chemistry, New York University. Second edition. D. Van Nostrand Company, Inc., New York City, 1937. xiii + 664 pp. 112 figs. 13.5 × 21.5 cm. $3.75.

This second edition of this text attempts to include an elementary presentation of those aspects of the subject which will enable the student to appreciate the present-day developments in the science. In order to accomplish this, the authors have introduced the development of the quantum idea and applied it to atomic and molecular systems. In addition, the treatment of the gaseous state and of reaction velocity is from a modern point of view. In the opinion of the reviewer, these changes are very stimulating and should increase the interest of the student, as well as the teacher. It is refreshing to find a textbook in physical chemistry so up to date in these topics. From an educational point of view, the influence of research on teaching is significantly illustrated, in that those topics which are so well presented are those with which the authors are actively associated. On the other hand, this high standard is not maintained in other topics. The chapters on solutions, electrical conductance and ionization, and ionic equilibria do not reach the high standard set in the other chapters. In particular, the treatment of transference numbers and conductance is somewhat disappointing. Nevertheless, the authors have brought forth a book which in many respects is superior to the texts previously available and merits the attention of progressive teachers in the field. The reviewer noted only one inconsistency in the presentation. The treatment of reaction velocity on page 548 is inconsistent with the treatment on page 502. The effect of electrolyte on the equilibrium constant is present in both cases.

MARTIN KILPATRICK

UNIVERSITY OF PENNSYLVANIA
PHILADELPHIA, PENNSYLVANIA

AL-RAZIS BUCH, GEHEIMNIS DER GEHEIMNISSE, mit Einleitung und Erläuterungen in deutscher Übersetzung von *Julius Ruska*. Quellen und Studien zur Geschichte der Naturwissenschaften und der Medizin, Band 6. Verlag von Julius Springer, Berlin, 1937. xii + 246 pp. 5 figs. 17 × 26 cm. RM 38.50.

In the opening paragraph Razi (Rhazes) states that he wrote this book for one of his young students who asked him to compile something concerning the performance of the secrets of the

art "that would be a guide that he might follow and a standard to which he could refer. . .I have expounded to him the science of the chemical art. . .and have written for him a concise, excellent book entitled: *Book of the Secret of Secrets*. With it the metals can be raised (in rank). . .and it degrades (the ennobled metal) and brings it to the original condition. This process I describe: . . .If I did not know that my days are numbered, and if my death were not so near at hand,. . .I would not have troubled to have set down all this in my book, nor would I have taken the pains to do this in so complete a measure. This, my book, treats of three subjects: The knowledge of materials, the knowledge of vessels, the knowledge of the process."

This chemistry text, written about one thousand years ago, still makes excellent reading, but beyond its entertainment value is the important fact that this work was recognized as a masterpiece and exercised a potent influence on the development of science. The course of alchemy followed two divergent channels. The first had its rise in the Egyptian cult of the ninth to the thirteenth centuries, which being based not on experiment and observation developed, when transplanted on European soil, into the welter of literary extravagances and arrant nonsense synonomous with the popular idea of alchemy. The second channel of development had its rise in the Syro-Persian culture which in time was transmitted to the Occident by the Arabs. This rested on the solid foundation of factual knowledge laid down by Razi, who avoided all magic and astrology. He and his successors were the forerunners of modern chemistry.

Several manuscripts of the text are known, but after careful comparison Ruska decided to base his translation on the one in the Göttingen library. Its probable date is 1561. Translations of medieval alchemical texts often suffer from the use of modern mineralogic and chemical terms as being proper translations of the vague and variable ideas that the alchemical writer called by these same names. The alchemists used dozens of names for the same material, and, contrariwise, one name was often made to serve for a variety of materials. Razi avoided this confusing practice; he used a straightforward style and described most materials in precise and unequivocal terms. Color, luster, hardness, taste, odor, fusibility, inflammability, etc., are given so that the recognition of the carriers of these qualities is usually certain, a circumstance that delivered the translator from many of the snares that beset the path of the unwary. At times, the terms used by Razi do not cover the modern meaning, as, for example, "magnisiya" is not magnesia but an ore of manganese. Such questions are handled in the extensive commentary (eighty-two pages) that precedes the translation itself. Apparatus and procedures are described in detail, and the state of development of equipment and the extent to which it was used are a revelation to those who may have believed that such chemical furniture and knowledge of reactions and behaviors are of a much later date than Razi (865–925). Certainly this type of alchemy is quite different from the mystic, allegorical rigamarole found in so many of the products of Greek alchemy and its dependent Arabian writers.

The aim of Razi's alchemy was to change baser metals into silver and gold, and to convert common rocks and minerals into precious gem stones. The means was a powder or water that was to act like a powerful medicament. The basic philosophy was that all materials are carriers of properties which can be increased or decreased by suitable elixirs, by heating, etc., or by the addition of other materials of like or opposite qualities. The basic qualities included those of earth, water, smoke, air, to which were added those of oil and sulfur, which conferred inflammability. Degrees of salinity also entered the picture. Here are the roots of the "mercury," "salt," and "sulfur" of the later alchemists.

Many of the procedures described by Razi are entirely or substantially valid; others, to us, are nonsensical, and the putative results are figments of the writer's imagination. However, Razi was the first to expound alchemy in a strictly scientific form, and this, his chief work, leaves the impression that the whole literature, which sets forth alchemy in separate chapters dealing respectively with materials, apparatus, and working directions, rests primarily on the presentation in the *Book of the Secret of Secrets*.

How could Razi, who was acknowledged to be one of the greatest physicians of his time, and who enjoyed the highest reputation as a clear-thinking philosopher, so deceive himself that, in all good faith, he could seriously write alchemical books? The answer is simple: other times, other philosophies. His ideology, one accepted, justified his procedures and aims, and his methods and goals were just as legitimate as those of modern chemistry, which are the product of our own scientific beliefs.

Was practical use made of this treatise on transmutation? The Göttingen manuscript contains an interesting insertion concerning attempts to prepare the elixirs: "Abu'lqasim al-Muqaddas—may Allah be merciful unto him—says: 'Verily, I have looked into this book and have seen there not even the slightest indication for bringing forth the spirit of the 'Alam and the 'Aqrab. Therefore, busy not yourself with these two, unless you already know the Secret of the Process—for only then—God willing—are you capable of the Work.' "

The foregoing is mostly adapted from the interesting commentary which Ruska has provided. In this elucidation he reveals his competent scholarliness and his complete understanding of this difficult subject matter. In the July, 1936, issue of THIS JOURNAL (page 313) may be found an essay "Ruska's Researches on the Alchemy of al-Razi." The author, R. Winderlich, also wrote the biographical sketch in the Festschrift issued in February, 1937, in honor of Ruska's seventieth birthday (Abhandlugen zur Geschichte der Medizin und der Naturwissenschaften, Heft 19). In these will be found the background of the laborious researches which enabled this man of transcedent talent and indomitable industry to put out this superlative discussion and translation of one of the classics of early alchemical, or should we say chemical, literature.

It is unfortunate that the high price will preclude a wide sale.

RALPH E. OESPER

UNIVERSITY OF CINCINNATI
CINCINNATI, OHIO

ORGANIC SYNTHESES, XVII. *L. F. Fieser*, Editor. John Wiley and Sons, Inc., New York City, 1937. v + 112 pp. 2 figs. 15 × 23 cm. $1.75.

The current volume of this valuable series contains directions for the preparation of: aconitic acid, γ-aminobutyric acid, ε-aminocaproic acid, 1,2-aminonaphthol hydrochloride and 1,4 aminonaphthol hydrochloride, benzoylene urea, bromal, ρ-bromobenzaldehyde, 4-bromoresorcinol, 1,3-butadiene, 2-carbethoxy-cyclopentanone, cellobiose, α-cellobiose octacetate, chelidonic acid, cholestanone, dihydrocholesterol, 2,4-dimethyl-5-carbethoxypyrrole, β,β-diphenylpropiophenone, ethyl ethoxalylpropionate, ethyl methylamolanate, unsym. heptachloropropane, 2-ketohexamethyleneimine, 6-methyluracil, β-naphthoic acid, β-naphthoquinone and α-naphthoquinone, pentaerithrityl bromide and iodide, α-phenylethylamine, d-and l-α-phenylethylamine, tetramethylene chlorohydrin, tricarbethoxymethane, and triphenylethylene. There follows an appendix containing "later references to preparations in preceding volumes," and "additions and corrections for preceding volumes."

This publication fills a very definite need, and it is particularly gratifying to note that many of the preparations reflect the trends of modern organic research.

NATHAN L. DRAKE

UNIVERSITY OF MARYLAND
COLLEGE PARK, MARYLAND

MOTION PICTURES OF THE WORLD, The Educational Film Directory. International Educational Pictures, Inc., 40 Mount Vernon Street, Boston, Massachusetts. 66 pp. 27.5 × 21.5 cm. Subscription price $0.50. (Two issues annually.)

This directory contains a list of film subjects which includes all countries, art, biography, entertainment, history, industry, nature, religion, science, sports, and transportation.

Behind MERCUROCHROME

(dibrom-oxymercuri-fluorescein-sodium)

HWD *is a background of*

Precise manufacturing methods insuring uniformity

Controlled laboratory investigation

Chemical and biological control of each lot produced

Extensive clinical application

Thirteen years' acceptance by the Council of Pharmacy and Chemistry of the American Medical Association

A copy of our First Aid booklet will be sent on request.

Hynson, Westcott & Dunning, Inc., *Baltimore, Maryland*

Still Available—

DR. VICTOR E. LEVINE'S

The VITAMINS

SINGLE COPY 35c; EXTRA COPIES 30c each

Sent PREPAID upon receipt of remittance

JOURNAL OF CHEMICAL EDUCATION
20th & Northampton Sts., Easton, Pa.

Back Copies Wanted

We wish to acquire a limited number of the following back numbers of the JOURNAL of CHEMICAL EDUCATION at 50¢ each.

1924 (Vol. I) Nos. 1, 2.
1925 (Vol. II) Nos. 8, 9, 10.
1926 (Vol. III) Nos. 1, 2, 3, 4, 7.
1927 (Vol. IV) Nos. 4, 9.
1931 (Vol. VIII) No. 11.
1932 (Vol. IX) Nos. 10, 11, 12.
1933 (Vol. X) Nos. 1, 9.
1935 (Vol. XII) Nos. 11, 12.

Journal of Chemical Education
Easton Penna.

Reprints of

The Report of the Committee on Correlation of High-School with College Chemistry

Entitled

"An OUTLINE of ESSENTIALS for a YEAR of HIGH-SCHOOL CHEMISTRY"

by

B. S. HOPKINS, L. W. MATTERN, WILHELM SEGERBLOM *and* N. E. GORDON

These reprints form a 12-page leaflet containing a revised list of Essentials for the help of high-school teachers of chemistry. The original list proved to be so useful in producing a closer correlation between the chemistry taught in preparatory schools and that offered in colleges, that it was deemed necessary to revise and rearrange it so as to keep it up to date.

OFFERED AT COST

SINGLE COPY 15c; EXTRA COPIES 10c each

Sent PREPAID upon receipt of remittance

JOURNAL OF CHEMICAL EDUCATION
20th & Northampton Sts., Easton, Pa.

TRADE ANNOUNCEMENTS

New Fan Cooled Squirrel-Cage Motors

Protected against abrasive dust, moisture, and corrosion, a new design of dual ventilated fan-cooled type CS squirrel-cage motors has been announced by the *Westinghouse Electric and Manufacturing Company*. They are designed for use in automobile factories, foundries, cement plants, coal timples, machine shops, steel mills, chemical plants, dye houses, tanneries, packing plants, etc., where severe service is required. They may also be installed out-of-doors without additional protection.

The motor frame contains two separate sets of air ducts, one internal set and one external set. The internal ducts are open in the interior part of the motor, and the external ducts are open on the outside of the motor frame. These two sets of ducts are separated by a common wall.

The heat-exchanger principle is used for cooling. An internal fan on the rotor circulates warm internal air through the internal ducts, the walls of which are cooled by the external fan blowing larger volumes of cool air through the external ducts, providing rapid transfer of heat from the motor and insuring long insulation life.

The housing is designed so that fresh grease enters the outside edge at the top of the bearing and excess or used grease is discharged at the bottom inner edge to the overflow sump. Since adding fresh grease automatically cleanses the used grease from the bearing, it is unnecessary to incur the expense of periodically dismantling the motor to clean the bearings. The used or excess grease may be readily removed from the overflow sump through a pipe plug ogening. The cartridge type bearings are fully protected when the rotor is removed.

Monochromatic Light Source for Spectrophotometric Work

The Lablamp, which is manufactured by the *American Instrument Company, Inc., Silver Spring, Maryland*, is a new monochromatic light source for spectrophotometric, refractometric, microscopic, and polarimetric measurements. It has an output of 3500 lumens of visible light and an efficiency twice that of an ordinary 500-watt incandescent lamp. Its effective light source is concentrated in a $1/10'' \times 1/2''$ space, making it especially useful in optics and spectrographic work.

A small quartz tube surrounded by a hard glass envelope absorbs most light below 0.32 micron in wave-length (ultraviolet), the latter being available, however, by removing the glass envelope. Of the total radiation, 25 per cent. occurs in the visible spectrum, as compared with 5 per cent. in the incandescent lamp. Only 1.9 per cent. of the output occurs between 0.60 and 0.76 micron, as compared with 27 per cent. in the incandescent lamp.

The lamp housing is adjustable to any angular position in a horizontal plane, and at any height from $5^3/_4''$ to $20''$ from the bottom of the base. Doors on three sides of the lamp housing are easily slid out and replaced by monochromatic filters for isolating the various spectral lines of mercury radiation.

It operates on 110–120 volts, 50–60 cycles A.C., also on D.C. when used with suitable converter. It is rated at 95 watts, together with reactor.

It weighs fourteen pounds and measures $5^1/_4'' \times 6^1/_2'' \times 17''$ high.

Rancidex

A rancidity retardant for vegetable and animal oils, fats, waxes, etc., has just been introduced by the *Glyco Products Co., Inc., New York City*, under the name of Rancidex.

This material is recommended for the retardation of rancidity, discoloration due to oxidation, etc., for all non-edible preparations where animal and vegetable fats and oils are used.

Rancidex is suggested for use in the textile, leather, lubricant, cosmetic, and other industries where rancidity, "souring," and discoloration due to oxidation are constant sources of worry and annoyance.

Further information can be obtained from the manufacturers, the *Glyco Products Co., Inc., 148 Lafayette St., New York City*.

The New Bausch & Lomb Microfilm Reader

By microphotography, tiny photographic prints, single motion-picture frame size, are made on safety film. Newspaper or textbook pages, portions of rare or valuable "out-of-print" publications, sketches, and illustrations are reduced to approximately $^3/_4$ in. by 1 in. Thus a roll of microfilm small enough to go into a vest pocket may hold as many pages as five large books. The reductions in bulk and copying costs are invaluable to science and literature. Bibliofilm or microfilm service is now available from several sources.

Naturally, these small film areas are too small for direct reading. The Bausch & Lomb Microfilm Reader provides the handy, inexpensive means for reading these microfilms. In just a few feet, the equivalent of several pages of literature or a complete book may be read or rapidly reviewed. Similarly, photographs, notes, and speeches can be visualized. The tiny photographs are enlarged to comfortable reading size by the Microfilm Reader. In addition, the Bausch & Lomb Reader is suited to the careful inspection of miniature camera negatives, single frame size. Double frame size negatives may be inspected in their entirety by slightly moving the film.

The Reader has an attractive black bakelite body and film frame. With its magnification of from seven and one-half to eight times, the equivalent of reading a standard page at normal reading distance is obtained. Lightness of weight and a convenient handle make for effortless reading over long periods. Standard motion-picture film enters at either side, and individual frames are moved into reading position quickly and easily.

In use, the reader is held so that light falls upon the diffusing screen back of the reading area. The reading lens is provided with focusing sleeve for individual adjustment.

Plating Solution Control

It is announced by the *Grasselli Chemical Company* that it is in a position to offer the trade test kits for the control of cadmium and zinc plating solutions. Three kits have been developed for this purpose:

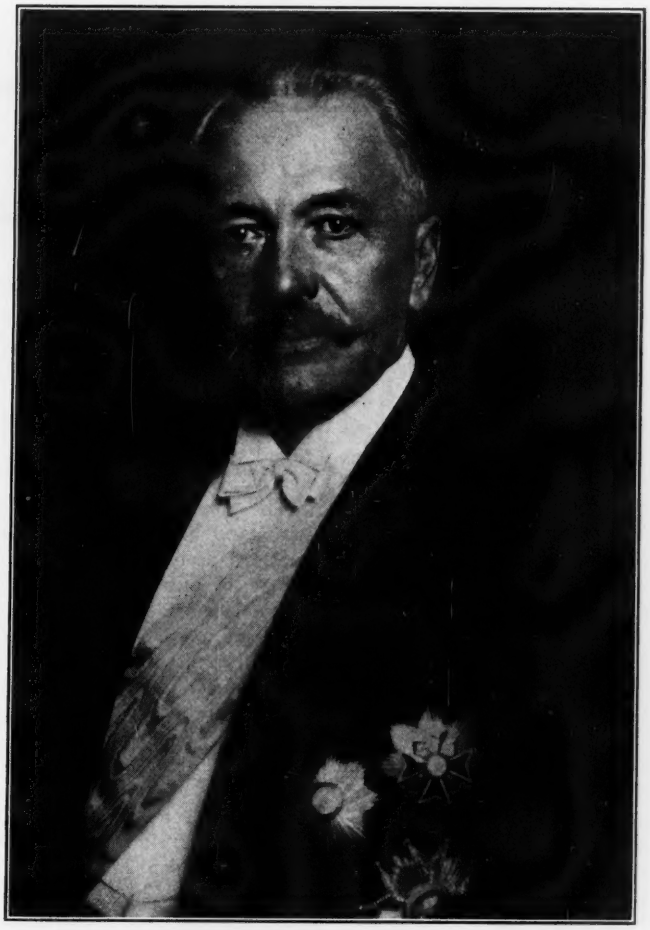
For the determination of cadmium in cadmium-cyanide plating solutions;

For the determination of zinc in alkali-cyanide or acid-zinc plating solutions;

For the determination of the total sodium-cyanide content in zinc or cadmium plating solutions.

These test sets for solution control supplement the Hull and Strausser test sets announced by *Grasselli* a few months ago for determining the thickness of electrodeposited cadmium or zinc coatings.

There is an increasing demand for coatings of specified thickness. These developments make it convenient for the plater to determine the composition of his plating bath and in that way keep it in the most efficient condition, enabling him to apply the specified coating thickness of cadmium or zinc in the minimum plating time.



DR. IGNACY MOSCICKI
President of the Polish Republic (1926–)

"The Polish Nation sees in the free and unhampered development of scientific thought, the surest guarantee of the progress and spread of universal civilization and culture."

Warzawa—The Castle
February 24, 1937

I. Moscicki

For biographical note contributed by Dr. Ralph E. Oesper, of the University of Cincinnati, see page 359. Dr. Oesper also lent the photograph here reproduced.

BOSTON UNIVERSITY
COLLEGE OF LIBERAL ARTS
LIBRARY

EDITOR'S OUTLOOK

NEW AIDS FOR THE LIBRARIAN. With the best will in the world the most capable of librarians is likely to find himself occasionally at odds with the faculty he undertakes to serve. Charged, as he is, with the acquisition, cataloging, and conservation of literary material for use, in the nature of things he must sometimes seek a feasible compromise between two conflicting desiderata. Two of his most pressing problems are the acquisition of rare or expensive material that is of use to only a few, but very important to the few who use it, and the conservation of standard material that is to be used year after year by large classes of students.

Considerable progress toward the solution of the first of these problems has now been made in the development of the technic and apparatus of "filmstating" discussed in these pages some time ago by Dr. Atherton Seidell [J. CHEM. EDUC., **12,** 415–8 (1935)]. The photographic equipment necessary to reproduction leaves little or nothing to be desired. Satisfactory reading devices are available, and wider use and continued improvements in design will undoubtedly still further reduce the comparatively moderate present costs of such equipment. Several of the larger university libraries, including the Harper Memorial Library of the University of Chicago, are now completely equipped. Reproduction service is available on a national scale through the Bibliofilm Service of Science Service, Inc.

The conservation of standard material that must withstand heavy usage year after year is in some respects a more vexing problem. Book orders may, of course, be duplicated and worn out books can usually be replaced. The replacement of several worn out pages of a bound journal volume, however, is often difficult, and the duplication of originals is usually out of the question. It may be that "filmstats" can play a part here also. At present the most practical solution of the problem for many institutions would seem to be that described elsewhere in these pages by Dr. Goldblatt.

Selected references from the literature are reproduced by an inexpensive photolithographic process, and each student is supplied at moderate cost with his own volume of literature readings. The reproduction process has been brought to a high degree of perfection, and the reproductions we have seen are quite as legible as the originals. To faculty members who sometimes accuse librarians of forgetting that libraries are for use, and to harassed librarians who sometimes feel that the impossible is demanded of them, we recommend mutual consultation on the feasibility of this plan.

NON-METALLICS *in the* CHEMICAL INDUSTRY

FREDERICK A. ROHRMAN

Michigan College of Mining and Technology, Houghton, Michigan

INTRODUCTION

THE ancients probably made use of non-metallics, such as wood and ceramic materials, long before they employed the common metals and alloys. The alchemists were dependent upon glass and earthenware apparatus for their experimentation and chemical production. Non-metallics may be called, then, the forerunners of all our materials of construction. (Actually, ceramic materials, as a class, have a more general resistance to corrosion and abrasion than any other known substances.)

Our chemical industry has advanced so rapidly that the demands placed upon materials of construction are enormous. The large-scale production of more corrosive products under much more severe conditions of pressure and temperature is a daily problem in our chemical and metallurgical industries. The use of non-metallics has increased proportionally with that of the metals and alloys. The improvement of the older and more common non-metallics, as well as the development of newer types, has been constant in all phases of the chemical industry. Research here has accomplished marvels. Chemical stoneware has been made stronger, lighter in weight, and more resistant to chemical attack; rubber and the synthetic rubber-like Neoprene are made to withstand higher temperatures and oxidizing conditions; inorganic materials are being added to the resinoidal condensation products so as to improve their physical properties; and glass is being produced which is more resistant to shock and rapid temperature changes.

The purpose of this paper is to present a review of the modern non-metallics in the chemical industry. This manuscript closes a series on materials of construction and corrosion which have appeared in THIS JOURNAL. A more complete review is obtainable by referring to the earlier contributions which appeared in the JOURNAL OF CHEMICAL EDUCATION for March, April, and May, 1933, and February and March, 1936.

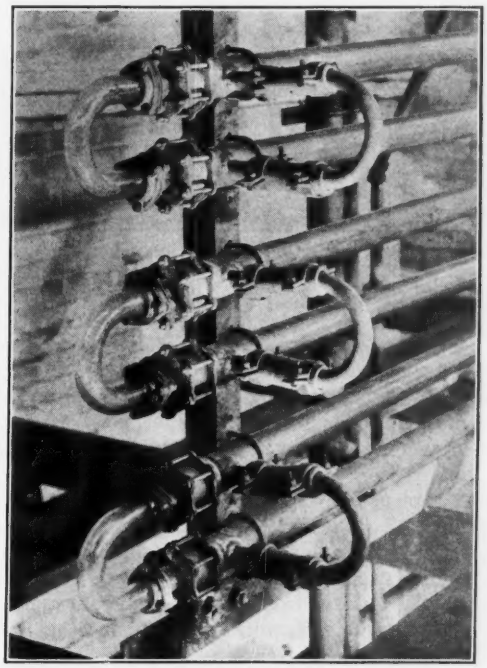
The non-metallics may be classified in two groups, the siliceous and the non-siliceous.

Siliceous	*Non-siliceous*
1. Glass and glass-lined products	1. Plastics
2. Chemical stoneware, heat- and acid-resisting brick	2. Rubber
3. Fused silica	3. Wood
	4. Carbon

It should also be mentioned here that the combined use of non-metallics with metals, taking advantage of both the strength and the chemical resistance of the different materials, is becoming more and more important. Examples of such materials are glass-lined steel and rubber-lined pipe.

GLASS AND GLASS-LINED STEEL PRODUCTS

The subject of glass as a material of construction involves both the solid and glass-lined (enameled) steel equipment. Borosilicate glass is used almost invariably for the solid glass equipment because of its ability to resist rapid thermal changes, while special enamels are employed for the lined equipment.

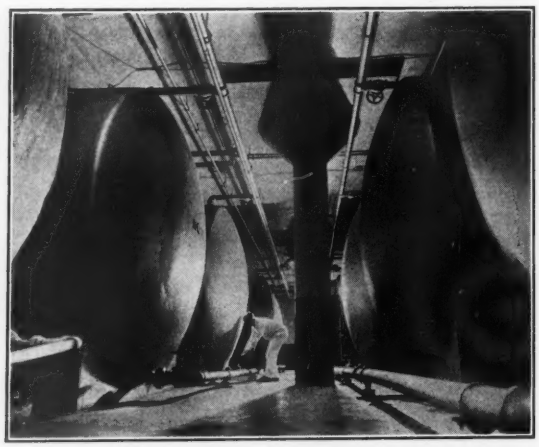


Courtesy Corning Glass Company

FIGURE 1.—STEEL-JACKETED PYREX GLASS HYDROCHLORIC ACID COOLER

From the physical point of view, glass equipment possesses both desirable and undesirable properties. The inability of solid glass equipment to withstand mechanical shock or strain is its chief disadvantage. Newer glasses are being developed, however, which demonstrate almost unbelievable resistance in these respects. The glass-lined steel equipment is quite

resistant to physical shock. Although glass is a poor conductor of heat, its surface condition is much more favorable toward heat-transmission than that of other materials, such as copper. This is because glass has a very thin solid-liquid interfacial film, more so than other materials. While the metals form films of corrosion products which become more and more pronounced with exposure, glass and glass-lined steel retain their smooth, clean surface. Thus, while



Courtesy The Pfaudler Company

FIGURE 2.—GLASS-LINED STEEL CONTAINERS

copper has about three hundred times the heat conductivity of glass, the over-all heat transmissability of copper equipment is only a few times greater than that of glass. Moreover, the conductivity of glass products is more uniform over a period of time.

The transparency of solid glass permits ready inspection of flaws in the equipment and appearance of the processed product. The freedom of glass from the usual ravages of corrosives encourages the manufacture of products free from contamination by the normal products of corrosion. Freedom from traces of contaminating materials is absolutely imperative in the manufacture of certain fine chemicals, pharmaceuticals, foods, and biological products. Figure 1 illustrates a section of a jacketed heat exchanger, the inner pipe being Pyrex glass and carrying hydrochloric acid, and the outer pipe being steel and carrying cooling water.

The resistance of glass to the normally corrosive chemicals is well known. Only a few chemicals attack glass; among the more common are hydrofluoric acid and hot acids which might contain traces of hydrofluoric acid, such as crude phosphoric acid. In many cases metals and alloys are quite unable to give satisfactory service because of the action of certain corrosives; consequently glass, as well as the other non-metallics, is employed.

The introduction of glass-lined equipment happily combined both the desirable properties of metallic strength and the chemical resistance of glass. Such equipment is being fabricated into many forms, shapes, and sizes and is finding considerable use in the chemical and pharmaceutical industries. Figure 2 shows some large glass-lined steel storage tanks employed by the Pepsodent Company for the storage of antiseptic solutions.

Two advantages of the newer solid glasses are their hardness and their high softening temperature, approximately 600°C. The former advantage permits the use of glass where erosion as well as corrosion is a factor.

RUBBER

Rubber and rubber-coated metals, although considered relatively new materials of construction, have been used for many years. One company has furnished rubber to the chemical industry since 1860. An installation of almost one thousand feet of large-size rubber pipe and its fittings has been used for salt water since 1894! Improvements in rubber products, as well as the development of the rubber-like materials Neoprene (Duprene), Thiokol, Plioform, and Koroseal, have made it possible to extend the uses of these materials.

When speaking of rubber, one must consider both soft rubber and hard rubber. The excellent erosion-resistance of soft rubber makes it very desirable for apparatus-processing both erosive and corrosive substances. Figure 3 illustrates several rubber-lined alloy-steel pebble mills employed for crushing and mixing phosphate rock with sulfuric acid. The use of any corrosion-resistant metallic equipment would be impracticable for this operation because of the abrasive action of the silica slurry and pebbles.

While rubber cannot be used with sulfuric acid stronger than 50 per cent., nitric acid stronger than 20 per cent., petroleum and its products, benzene, aniline, and many other organic chemicals, its twin, Neoprene, resists all but the strong acids mentioned. Soft rubber will withstand temperatures as high as 80°C., while hard rubber and Duprene are stable at even higher temperatures. Within the last few years Germany has made great advances in "synthetic" rubber manufacture and application. According to Germany's new economic plans, she is striving to be independent of vegetable-product rubber in the near future and is producing from four to sixty tons of synthetic rubber each day. Rubber-lined equipment is used extensively for acid-pickling tanks, tanks for transporting and storing hydrochloric acid as well as other acids, and for the manufacture of phosphoric acid and many other liquid inorganic chemicals.

Hard rubber, containing up to 50 per cent. sulfur and other inert materials, lends itself to machining and can be fabricated into almost any shape and used for solid-rubber equipment; but a far greater amount of the hard rubber is used in combination with steel. In the latter case, the steel is first cleaned and then covered with a

rubber-to-metal adhesive. The compounded, uncured rubber stock is then applied to this surface and vulcanized. The resulting product gives excellent chemical and physical resistance. It has a tensile strength as high as 10,000 lb./sq. in. and a dielectric resistance of 1200 volts/mil. It is even more resistant to chemical action than soft rubber. Pumps, buckets, barrels and drums, pipes, and tanks are available in hard rubber.

WOOD

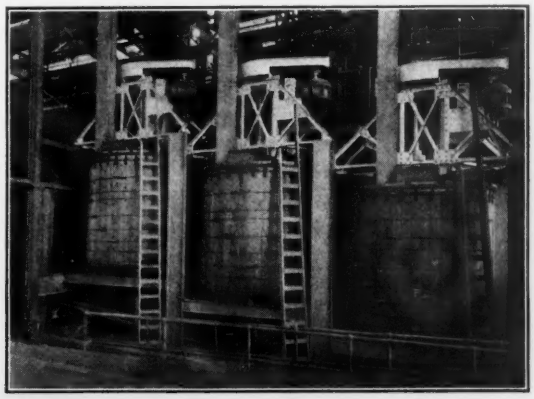
Wood is probably the oldest known material of construction. In the chemical industry wood is used in contact with a wide range of chemicals in reasonable concentrations. The great advantages of wood over other materials of construction are the ease with which it may be fabricated and repaired, its low cost, chemical resistance to low concentrations of many substances, low heat conductivity, and good adherence to paint and varnishes.

Courtesy of the Consolidated Mining and Smelting Company of Canada

FIGURE 3.—RUBBER-LINED PEBBLE MILLS

There are a number of woods used in the chemical industry, long-leaf yellow pine, cypress, Douglas fir, maple, oak, California redwood, white cedar, and poplar. Long-leaf yellow pine appears to resist solutions better than the other woods. Cypress does not impart any taste or color to water. Oak has the least expansion in most solutions. Poplar has been used for alcoholic solutions.

A wood tank, unlike a metallic tank, is a poor conductor of heat, and, consequently, holds liquids at a more constant temperature, and requires less heat to prevent freezing in winter, a very great advantage in many cases. It also requires painting less frequently than iron and steel tanks.



Courtesy The Dorr Company

FIGURE 4.—AGITATION SYSTEM OF PHOSPHORIC ACID MANUFACTURE

Nitric acid, strong hydroxide solutions, and concentrated hydrochloric and sulfuric acids exert the most severe action upon wood, and, consequently, are not employed in the presence of wood equipment. Many brines, water-softening solutions, tanning solutions, sulfite liquors, alum solutions, wood pulp, etc., are handled satisfactorily with wood equipment.

The use of rubber- or lead-lined wood equipment has extended the use of this material of construction. Figure 4 shows a series of lead-lined, wood agitation tanks employed in the manufacture of phosphoric acid. Many other chemicals directly destructive to wood can be readily processed in such lead- or rubber-lined equipment.

FUSED SILICA

Fused silica, or fused quartz, may be considered as the most effective heat- and chemical-resisting material known to industry. Quartz is a very common substance, but its application to industry is relatively recent. Although the fused and the natural product are similar chemically, the former has better physical properties as a material of construction. Two common trade names for fused silica products are Amersil and Vitreosil. The manufacturers of fused silica ware have made great progress in the fabrication of their products into useful apparatus.

Fused quartz, being non-crystalline, may be obtained in three varieties: opaque, translucent, and transparent. The opaque and translucent forms are somewhat

cellular in structure because of the presence of bubbles, while the transparent form is nearly free of bubbles. The physical properties of all three forms are practically identical. Only small pieces of apparatus are made of the transparent fused product.

Silica products are attacked only by hydrofluoric acid, basic metal compounds, molten alkalies, and some oxides at high temperatures which accelerate devitrification. Fused silica is extremely resistant to high temperatures. It has a softening temperature as high as 1500°C. and a safe working temperature of 1100°C. The low coefficient of expansion of fused silica—one seventeenth that of ordinary glass or platinum—makes it extremely useful for apparatus or equipment subject to sudden temperature changes. However, prolonged exposure to high temperatures favors transformation to the crystalline form. An unusual property of this material is its ability to transmit light in the wave-length region of ultra-violet. Physically, it is subject to fracture, like glass, and, consequently, it must not be subjected to any possible mechanical stress or strain.

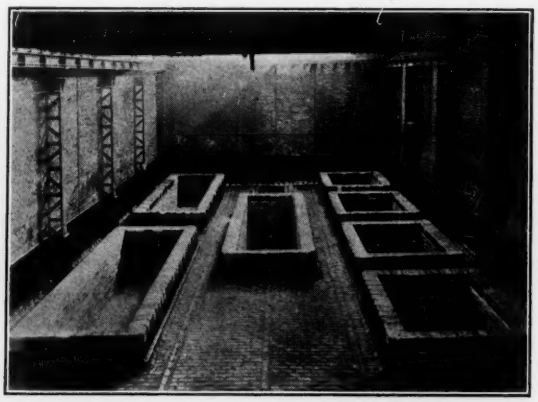
Courtesy Westvaco Chlorine Company

FIGURE 5.—FUSED-SILICA HYDROCHLORIC ACID UNIT

In chemical plants, fused silica apparatus is used for pipes, absorbers, cooling coils, etc., for the manufacture of hydrochloric, nitric and sulfuric acids, chlorine, etc. Figure 5 illustrates a section of a hydrochloric acid cooling and absorbing unit made of fused silica. It is used extensively for the manufacture of laboratory apparatus of all kinds, sizes, and shapes.

ACID-PROOF STONEWARE AND MASONRY

The use of stoneware and masonry as materials of construction dates from the earliest times. The production of sulfuric, nitric, and hydrochloric acids and many other chemicals was based upon the use of these materials. Today these materials are extremely important as materials of construction in many phases of chemical manufacture. The modern metals and alloys have been unable to keep up with the demands and the pace of many branches of the chemical industry, while these ceramic materials have been constantly improved, and their uses have been extended.



Courtesy Custodis Construction Company

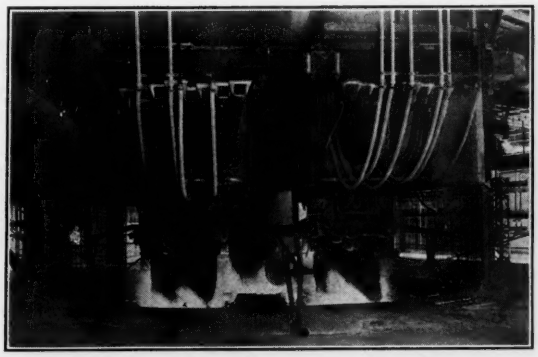
FIGURE 6.—ACID-PROOF MASONRY PICKLING TANKS

Modern chemical stoneware should not be likened to common earthenware. There is as great a difference between earthenware and chemical stoneware as there is between iron and "stainless steel".

Chemical stoneware is not a finished scientific product in comparison with other materials on the market. According to the latest scientific research in which the chemical and physical constitution of stoneware has been investigated, it is a vitrified, opaque, ceramic body possessing a variable chemical composition. The materials introduced to make up stoneware can be varied over wide ranges by the addition, or elimination, of different substances in small or large quantities. Chemically, stoneware consists of complex compounds of alumina and silica with various basic oxides. Physically, chemical stoneware is a mixture of crystalline and amorphous materials, the nature and relative quantities of which determine the usefulness of the product. The materials most often used are clay and kaolin as the plastic constituents, and feldspar and silica as the nonplastic components. The materials constituting stoneware are pulverized, usually washed, and then mixed in the desired proportions. The body is formed into

the desired shape by a variety of methods and dried slowly under controlled conditions of temperature and humidity; then it is heated to the vitrification point—about 1250°C. Most stoneware is finally salt-glazed to a pleasing red-brown color to improve the appearance and increase the ease of cleaning. Special bodies can be supplied with white or colored glazes.

Ordinary grades of stoneware should not be subjected to sharp temperature changes or used at temperatures much above 100°C., although special bodies, which have been developed recently, withstand much more



Courtesy Det Norske Aktieselskab for Elektrokemisk Industri

FIGURE 7.—CARBON ELECTRODES IN THE PRODUCTION OF CARBIDE

severe thermal shocks. The product is strong and comparable to grey cast-iron in its resistance to physical shock. The chief disadvantage of stoneware, as of the other ceramic materials, is its high elastic modulus.

Recently, there has appeared in the industry an improved stoneware made by a process called "de-airing," which gives a product having a close-grained body of low porosity. Such a body has a higher coefficient of heat transfusion, greater chemical resistance and mechanical strength, and the ability to be formed into thinner wall sections.

Stoneware is formed into tanks, storage vessels, jars, mixers, pumps, filters, piping, valves, towers, gas generators, absorption systems, etc., for handling acids, salts, and many other chemicals and pharmaceutical products.

Acid-proof masonry and stoneware are not competitive products. The size of the kilns in which stoneware is fired and other manufacturing limitations restrict the dimensions of stoneware bodies. Recourse must then be had to acid-proof brick or brick-lined structures. The success of this type of material is probably more dependent upon the cementing or binding material than upon the brick itself. Acid-proof brick is a form of ceramic ware possessing more porosity and less strength and chemical resistance than stoneware. Since acid-proof brick is somewhat porous, it usually "weeps," so that liquid-tight membranes, or double walls with intervening air spaces, are employed in most examples of such construction. Careful design and workmanship are necessary to insure ideal construction. Round tanks and towers are preferred, as the forces of expansion are more evenly distributed. Steel and concrete are the most desirable for lining, while wood is to be avoided.

A new type of construction, called Zeta Construction, has made it possible to build apparatus heretofore con-

Courtesy L. D. Vorce

FIGURE 8.—CARBON ANODE UNIT FOR ALKALI-CHLORINE CELL

sidered impracticable. Such construction depends upon the peculiar shape of the bricks which permit interlocking in such a way as to even the stresses and eliminate the necessity of buckstays, tie rods, and bands.

Acid-proof masonry is employed for pickling tanks, fume stacks, flues, storage tanks, autoclaves, towers, floors, and walls. Figure 6 illustrates a group of pickling tanks made of acid-proof masonry.

AMORPHOUS CARBON AND GRAPHITE

Few people realize that carbon products are utilized as important materials of construction. Carbon is a most effective heat- and chemical-resisting substance. Amorphous carbon and graphite differ in that the former is considered as being amorphous carbon and the latter crystalline carbon.

Carbon resists the action of strong alkalies, hydro-

fluoric, phosphoric, and oxidizing acids, and moist chlorine. It is attacked, however, by oxidizing gases at high temperatures and by a few chemical agents like fuming sulfuric acid and chromic acid. It will withstand the highest temperatures in the absence of oxidizing agents (over 4000°C.) without fusion or volatilization.

It is used in the form of bricks for constructing tanks to hold corrosive chemicals and lining the electrolytic

Courtesy of Bakelite Corporation

FIGURE 9.—BAKELITE MOLDED SPINNING POTS FOR THE RAYON INDUSTRY

tanks for the production of aluminum. It is formed into many shapes for Raschig rings in distilling columns and scrubbing towers, and for electrodes for the manufacture of electrolytic chlorine, caustic, hypochlorite, sodium, and magnesium metals. It is absolutely indispensable as electrodes for the high temperatures involved in manufacturing carbides, phosphorus, phosphoric acid, carbon disulfide, sodium, etc. It may be of interest to note that Söderberg self-baking carbon electrodes, which are fifty-four inches in diameter, are used in the manufacture of calcium carbide! A few years ago ten-inch electrodes were the largest employed. Figure 7 illustrates the use of these large electrodes (1200 mm. in diameter) in the manufacture of calcium carbide.

Figure 8 shows a Vorce alkali-chlorine electrode assembly with its ring of carbon bars acting as anodes.

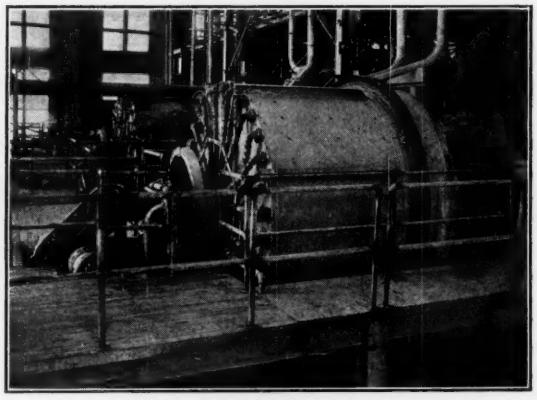
PLASTICS

Enlightened people have often called this the Age of Alloys. As time progresses, a new era will surely appear—the Plastic Age. The story of the evolution of these "disagreeable tars" and "strange esters" into light-weight, durable, and attractive, useful objects reads like a page from Andersen.

In 1936 the total production of plastics in this country approached one hundred million pounds. However, only a small percentage of this production has gone into the chemical manufacturing industry.

Organic plastics, as a class, may be considered as those synthetic resins and esters which are amenable to forming solid, durable objects. The plastics which are in use today and those showing great promise are the cellulosic esters, the phenol-formaldehyde, urea, vinyl, styrol, casein, furfuraldehyde, acrylic, and soybean resins and their mixtures with inert materials. Plastics made from these substances have well known trade names such as Bakelite, Celluloid, Haveg, Vinylite, Micarta, and Lucite. There are hundreds of different plastics on the market today, although only a few have any industrial significance.

Haveg, a phenol-formaldehyde mixture with asbestos, has found a great number of uses in the chemical industry. This material will withstand a temperature of 130°C., has one-fifth the weight of iron and a tensile



Courtesy Consolidated Mining and Smelting Company, Ltd.

FIGURE 10.—BATTERY OF FILTERS

strength of 6000–12,000 lb./sq. in. It is resistant to all but the oxidizing acids, strong hydroxides, and organic bases like pyridine and acetone. It has been formed into tanks which have a capacity of over four thousand gallons, scrubbing and reaction towers, dyeing vats, liquid and fume duct piping, fans, crystallizing dishes, agitators, and filter presses.

Bakelite, the best known of the synthetic resins, consists of pure phenol-formaldehyde resin. Like Haveg, it can be molded and machined into any desired shape. Although Bakelite is employed chiefly outside of the chemical industry, it has several very unique uses in the latter. Figure 9 illustrates a Bakelite spinning pot for use in the manufacture of fine rayons. This pot must withstand the action of sulfuric acid, sulfur, and carbon disulfide.

Figure 10 shows a battery of vacuum filters equipped with "Doracid," nitrated cotton filter cloth for the purpose of filtering slurries in the manufacture of phosphoric acid by the wet method. Metallic or cotton filter cloth would be unable to withstand the corrosive action of the acids.

The importance of these plastics is probably a story for the future. As our knowledge of these materials increases, it is not inconceivable that they will be made cheaper, more chemically resistant and will bear most desirable physical properties. The Age of Plastics is near!

ACKNOWLEDGMENTS

The writer is very grateful to the many industrial organizations manufacturing non-metallics who have so kindly assisted in making this paper possible. Dr. Ella Wood and Dr. Lyle Rose, of this institution, are thanked for their valuable suggestions and editorial assistance during the preparation of the manuscript.

IGNACY MOSCICKI*

IGNACY MOSCICKI, chemist and statesman, was born at Mierzanow, Poland, in 1867. After his graduation from the Polytechnic at Riga in 1891, the young engineer spent several years in England where he gained valuable industrial experience. In 1897 he was appointed assistant to Kowalski, the physicist, at the University of Freiburg (Switzerland). Here began his real scientific career.

The dire predictions of Crookes in 1898 had brought the fixation of nitrogen to the serious attention of the chemical world, and the use of the electric arc to bring about the union of nitrogen and oxygen was being studied by chemists and physicists, particularly in countries blessed with considerable water power. In 1903, a semi-industrial plant was constructed by Moscicki at Freiburg, but the publication of the results of Birkeland and Eyde led him to abandon his original ideas and to attack the difficult problem from another direction. His new design centered around an arc that was kept constantly rotating by the action of a magnetic field. The unit was put into operation in 1905 and attracted wide-spread interest. Einstein, then attached to the German Patent Office, made a special trip to Switzerland to see the Moscicki furnace, as did Crookes. Later, this design was used on an industrial scale at Chippis, and this plant was the sole producer of nitrates in Switzerland during the war.

The large scale use of the arc brought with it the problems of high tensions, which were being used industrially for the first time. Moscicki devised condensers capable of withstanding voltages as high as 100,000 and he introduced them for the protection of electric networks against atmospheric influences.

The important problems of absorbing the nitrous gases and of concentrating the dilute solutions were successfully met, and in 1910 the first shipment of concentrated nitric acid produced electrothermically came from this Swiss plant.

Moscicki, about this time, worked out another important synthesis, namely the preparation of hydrocyanic acid from nitrogen and hydrocarbons. Several years later this process was put into practice in Poland.

In 1912 he was recalled to his native land, as professor of physical and electrochemistry at Lwów. From then on he turned most of his attention to the problems of Polish chemical industries, particularly petroleum. Noteworthy was his work on the breaking of emulsions, fractional distillation, extraction of gasoline from natural gas, chlorination of methane, etc.

In order to advance interest in this type of research, he organized "Methane," a society devoted to the scientific and industrial aspects of the oil and gas industries. The organization was later transformed into the "Institute of Chemical Research," whose province includes all fields of chemistry.

After the war Moscicki's activities revolved around the development of the chemical industries of his Fatherland. The nitrogen industry of Poland is practically his creation, and the new plant at Moscice, built almost entirely from his plans, is a model of its kind.

Deservedly popular for what he had contributed to the welfare of his country, this eminent man of science and technology, to whom the Polish chemical industry owes so much, was made President of the Polish Republic in 1926. Not the least among his other notable qualifications was the fact that he had not previously engaged in political activities. He served with such distinction that he was elected for a second seven-year term in 1933. No chemist has ever occupied such a high political position, and his career is a shining example of the truth of the idea that a scientific training is the best preparation for governmental responsibilities.

(*Contributed by Ralph E. Oesper, University of Cincinnati.*)

* See frontispiece.

CHEMICAL WARFARE *in the* MIDDLE AGES*

KALLINIKOS' "PREPARED FIRE"

NICHOLAS D. CHERONIS

Chicago City Colleges, Chicago, Illinois

THE earliest reference to Kallinikos appears in the work of Theophanes the Confessor, or Saint Theophanes, a chronicler who lived at the middle of the eighth century (758–817), and recorded the history of the Eastern Empire from 284 to 813.

The period of the seventh century is considered by historians as the darkest period of the Byzantine empire. The birth of Islam[1] is one of the important landmarks of this century. By 650 A.D. the Arabs had conquered the greater part of the eastern world, Syria, Palestine, Mesopotamia, Egypt, Asia Minor, and Armenia; and after they acquired a fleet under the Kalif Moavia, the Saracens appeared before Constantinople in 670† and besieged it. The emperor of the Eastern Empire was Constantine IV, surnamed Pogonatus (the Bearded), who had been reigning only two years. According to Theophanes he was informed of the designs of the unbelievers, and prepared for a vigorous defence. A year before Kallinikos and his newly discovered "marine fire" are mentioned, the following passage appears.

"Constantine, being apprised of the designs of the unbelievers against Constantinople, commanded large boats equipped with cauldrons of fire (tubs or vats of fire) and fast-sailing galleys equipped with siphons."[2]

This passage clearly indicates that there was consideration of the use of incendiary materials, and that there were galleys with mechanisms called "siphons". In the same passage by Theophanes we read on for the next year the following.

"At this time Kallinikos, an architect from Heliopolis of Syria, came to the Byzantines and having prepared a 'sea fire' (or 'marine fire') set fire to the boats of the Arabs, and burned these with their men aboard, and in this manner the Byzantines were victorious and found the 'marine fire'."[3]

Another chronicler, George Cedrenus, who wrote about the middle of the eleventh century, gives the following passage about Kallinikos.[4]

"Then Kallinikos, an architect from Heliopolis of Egypt, came to the Byzantines and having made a 'marine fire' burned and sank with every soul aboard the ships of the Arabs in Cyzicus. This is the man who discovered the 'marine fire' and from him is descended the family of Lampros which today compounds with art (scientifically) the fire."

FIGURE 1.—DRAWING BY FELDHAUS SHOWING A WARRIOR SHOOTING FIRE WITH THE HAND-OPERATED "STREPTA"

There is another reference to Kallinikos in the book of Constantine VII (Porphyrogenitus 912–959) entitled "De Administrando Imperio" which was written for his son Romanus, to give him an account of the condition of the empire.[5]

"Let it be known," writes this emperor, "that during the reign of Constantine Pogonatus, one Kallinikos, having fled from Heliopolis to the Byzantines, prepared the liquid fire, which by siphons (is ejected) and

* Based on a paper presented before the Division of History of Chemistry at the eighty-sixth meeting of the A. C. S., Chicago, September 14, 1933.

† The exact date may be 672.

[1] DIEHL, "History of Byzantine Empire."

[2] THEOPHANES, "Chronographia," A.M. 6164, A.C. 664; MIGNE, "Patrologiae Graeca," Tomus CVIII, p. 720.

[3] *Ibid.*, A.M. 6165; CVIII, p. 721.

[4] CEDRENUS, "Συνοψις Ιστοριῶν," ed. Becker, Bonn, **1839**, p. 765.

[5] CONSTANTINE PORPHYROGENITUS, "De administrando imperio," ch. **48**, 20.

through which the Byzantines burned the fleet of the Arabs in Cyzicus (and) obtained victory."

We may then safely assume that Kallinikos lived during the middle of the seventh century, that he was an architect, and that he lived either in Heliopolis of Syria, or more probably in Heliopolis of Egypt. This latter town was one of the principal fortified towns of Byzantine Egypt.[6] Kallinikos then may have come into contact with the scientific knowledge of the Alexandrian school. So, whatever his origin was, it is definite that he introduced to the Byzantines an innovation in the known methods of chemical warfare; for there is ample historical evidence to show that the Byzantines, using this "fire" of Kallinikos, routed the Saracens in their first attempt to take Constantinople between 670 and 678, and destroyed most of their vessels.

Again, in 717, the Arabs launched another assault against the capital of the Eastern Empire; they invested Constantinople closely by land from both the European and the Asiatic sides, and by sea with eighteen hundred vessels. Leo III, then Emperor, relying on Kallinikos' fire, caused a terrific destruction of the fleet, "while hunger and the extremely severe winter of the year 717–718 completed the final defeat of the Moslems."[7]

This defeat saved the Eastern Empire, as well as western civilization from Islam.

Kallinikos must have obtained an important position under the Emperor, and if we believe the chronicler Cedrenus, his descendants were close to the royal court and were engaged in preparation of the "prepared fire".

The mixture is referred to as "marine fire" and "prepared fire" by Theophanes[8] and Cedrenus,[9] and as "fluid" or "liquid fire" by Constantine VII,[10] and Princess Anna.[11] By Leo the Wise[12] it is called "prepared fire". Its composition was vigilantly guarded by the government. Leo III states that the composition was known to himself and a few others.

There is ample historical evidence that besides the use in the combats already referred to, Kallinikos' fire became the chief weapon of the Byzantines. They used it, not only against the Arabs, but against the Russians, Pisans, and all the others who continuously attacked the Eastern Empire. It may be rightly said that Constantinople was the butt of the attack from the Asiatic invaders, and that relying chiefly on Kallinikos' fire they were able to resist for several centuries.

Therefore, it appears certain that Kallinikos introduced an innovation in the mode of chemical warfare, in the form of a prepared liquid composition which was used mostly in sea combat, being ejected by tubes called "*siphons*" onto the enemy's boats and thus setting them on fire. This mode of warfare was not new. A brief review of historical references will be given to show that the use of "fire" and incendiary projectiles is known historically as early as the fifth century B.C.

Homer mentions in the "Iliad"[13] the attempt of Hector to burn the Greek vessels but mentions no materials. Again, on Assyrian bas-reliefs of the eighth century B.C., are found pictures of warriors throwing burning oil, using torches, or extinguishing fires set by other warriors. Herodotus, in describing the battle of Marathon, states that when the Athenians routed the Persians and chased them to the sea,[14] they "asked for fire and rushed into the sea" (to burn the boats of the Persians). No mention of materials is made. From another description in Herodotus[15] it is evident that the Persians knew petroleum and its properties, and when under Xerxes they came against Greece, the first reference to incendiary projectiles appears as an arrow bearing a piece of tow with a burning composition.[16]

This type of warfare, then, it seems, was introduced to the Greeks by the Persians, and the Greeks were not slow in adopting it, for not long after the rout of the Persians the various commonwealths of Greece began a civil war, and during this long struggle instances of chemical warfare are discovered.

Thucydides relates that in the third year of the war (that is, in 429 B.C.) the Peloponnesians were hard pressing the city of Plataea and were trying by every method to take possession of the city.[17] When all their attempts had failed, they filled up the hollow near the walls with fagots steeped in pitch and sulfur. A flame was raised such as had not been seen before. Thucydides compares it to a burning forest. The fire would have destroyed the city if a storm of rain had not quenched it.

Four years later the opponents of the Athenians made use of sulfur and pitch fire again, but this time they used something like the "Flammenwerter" against the walls of Delium.[18] Also, incendiary materials were used by the Syracusans during the nineteenth year of the war.

As time went on, along with other improvements in life, improvements in the modes of warfare were also made. A general, Aeneas by name, compiled the first treatise on the art of war. This book was adopted by the Romans and was used until the end of the empire. The book is named "Poliorkitica" or Siegecraft, and was written between 350 and 356 B.C. It gives directions on city guards, signals, gate sentries,

---

[6] MASPERO, "Organisation militaire de l'Égypte Byzantine," Paris, 1912.
[7] VASILIEV, "History of the Byzantine Empire," Vol. I, p. 288.
[8] *Ibid.*
[9] *Ibid.*
[10] *Ibid.*
[11] Alexias XI, 10.
[12] Leo the Wise: Τακτικά Διάταξις, ιθ'; MIGNE, "Patrologiae Graeca," Tomus CVII, ch. 13.
[13] Iliad XVI, 123.
[14] Herodotus VI, 113.
[15] Herodotus VI, 119.
[16] Herodotus VIII, 52.
[17] Thucydides: ii, 77.
[18] *Ibid.*, IV, 100.

methods of sending secretly letters and codes, types of inks, etc. Chapter 35 deals with the preparation of fire.[19]

"You make a fierce fire, which is impossible to put out, with the following: pitch, sulfur, tow, pounded gum olibanum, and pine sawdust. Put these in a vessel, set a light to them, and apply them to any articles belonging to the enemy which you wish to catch fire."

The Romans adopted these methods of chemical warfare and references to fire arrows, and fire lances, discharged from machines are found. In Vegetius Renatus (about 350 A.D.), the composition of the inflammable material of the fire arrows is given as "sulfur, bitumen, rosin, and naphtha."[20]

It is clear, therefore, that incendiary projectiles were known to every general of antiquity. It is difficult to suppose that Kallinikos' fire was exactly the same type as either Aeneas' or Vegetius'.*

It appears reasonable that Kallinikos worked and experimented with known methods of warfare, and it seems probable that he hit upon a preparation which could be used much more effectively than the composition hitherto used.

In approaching the topic of the composition of Kallinikos' fire it is clear that any explanation or hypothesis as to its composition must satisfy the following conditions. It must explain the mode of ejection as described in the historical documents of that period, particularly the directions given in Leo's Tactica, and it must also explain the mode of action of the composition.

Leo's Tactica is a treatise on military tactics written about 900 A.D., for the generals of the empire. Instructions are given as to organization, transportation, supply, and methods used in combat. The following are exact translations of the significant and important passages.[21]

"8. . . . . and of the last two oarsmen in the bow, let the one be the *siphonator*, and the other to cast the anchors into the sea.

"6. In any case, let him have in the bow the *siphon* covered with copper, as usual, by means of which he shall shoot the *prepared fire* upon the enemy. And above such *siphon* (let there be) a false bottom of planks also surrounded by boards, in which the warriors shall stand to meet the oncoming foes.

"45. On occasion (let there be) formations immediately to the front (without maneuvers) so whenever there is need to fall on the enemy at the bow and set fire to the ships by means of the *fire of the siphons*."

"51. Many very suitable contrivances were invented by the ancients and moderns, with regard to both the enemy's ships and the warriors on them—such as at that time the '*prepared fire*' which is ejected (thrown) by means of siphons with a roar and a lurid (burning) smoke and filling them (the ships) with smoke.

"70. They shall use also the other method of small *siphons* thrown by hand from behind iron shields, and held (by the soldiers) which are called '*hand siphons*' and have been recently manufactured by our state. For these can also throw (shoot) the prepared fire into the faces of the enemy.

"53.[22] And against the scaling ladders which are brought up to the walls or against those who dare approach, (throw) stones and boiling pitch and oil and 'tilis' . . . . . Against the wooden towers, however, which are brought up on rollers and which are called by the tactician '*mosynes*,' the so-called 'strepta' are useful, which eject the liquid fire (many indeed call this 'brilliant') mechanically. And also the so-called hand-siphons which our royal state has now developed (are useful)."

Besides Leo's Tactica, there is evidence as to the mode of ejection and the use of fire in sea combat from Princess Anna Comnena, who may be considered the most reliable historian of the Byzantines. Anna, the daughter of Alexius, Emperor of Constantinople from 1081 to 1118, writes in a style which is closer to the classics than any other writer of the Byzantine period. In relating the story of the war between the Pisans and Byzantines, she says,[23]

"Captain Eleemon impudently attacking a very large ship at the stern, and falling on its rudders and, not being able readily to make his way through there, would have been captured had he not promptly looked after his equipment and shot fire at them with a good aim. Then quickly veering about he immediately set on fire three very large ships of the barbarians . . . . . the barbarians were thoroughly frightened, for one thing on account of the '*fire*' hurled at them (for they were not accustomed to such implements or *fire*, naturally having an upward tendency, yet being shot by the shooter at whatever he might wish both downward and frequently to either side)."

From the foregoing evidence it may be assumed that

1. Kallinikos' "prepared fire" was of liquid composition. There is no evidence that claims it was a projectile.

2. The fire in sea combat was ejected through tubes referred to as *siphons* by a special man called "*Siphonator*". Also in land or sea combat it was ejected by a hand-worked apparatus called *handsiphon*.

3. Later, we find reference to another mechanism called "*strepta*". This word may be explained to suit one's theory. It may be taken as an instrument which

---

[19] "Αι'νει'ου Πολιορκητικα'" ch. XXXV, ed. L. W. Hunter, Oxford, 1927.

[20] VEGETIUS RENATUS, "De re militari," Bibl. Scropt. Crasc. & Rom. Teubneriana, Leipsig, 1874, ch. XXXV, p. 79.

* *Note:* The story of Proclus the Athenian who, by a powder of "native sulfur" (Θειον 'απυρον) burned the fleet of Vitalian during the fifth century, is related by I. Malalas the Chronicler. The description is too vague to be considered of any historical value. (Malalas Chronographia; ch. XVI.)

[21] Leo's Τακτικα', J. P. Migne, Patrologiae Graeca, Tomus CVII, ch. 19. (*Italics ours.*)

[22] Appendix to the Tactica, added about the eleventh century.

[23] Anna Comnena, Alexias XI, 10.

is twisted or flexible, etc., or an instrument which is discharged by turning.

4. The ejection was followed by roar (thunder) and lurid or burning smoke.

5. It spread rapidly; water could not put it out; later (twelfth century), it is written that it stank abominably and did not go out even if it fell upon stone or iron, but continued to burn until it was consumed.

We may now take the various hypotheses which have been proposed with reference to its composition. The

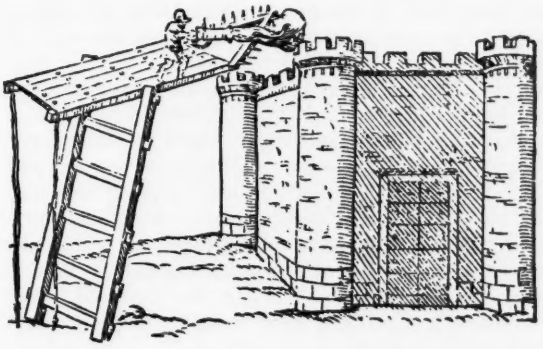


FIGURE 2.—ANOTHER DIAGRAM FROM THE 1693 EDITION (PARIS) OF THE VETERUM MATHEMATICUM, SHOWING A WARRIOR SHOOTING FIRE UPON THE DEFENDERS OF A FORT WITH THE HAND-OPERATED "STREPTA"

first assumes that Kallinikos' fire was a composition of the "Aeneas type" of incendiaries—that is, rosin, asphalt, pitch, sulfur, and naphtha, with finely divided quicklime. This, of course, required that it should fall on water so that the heat of the hydration should ignite the combustible vapors. von Lippmann[24] devoted a great deal of space to this explanation. It fails, however, to convince. First, this was known to the Alexandrians. Berthelot[25] in his extensive writings on the composition of incendiary materials of antiquity and the middle ages shows that Julius Africanus in the third century gave formulas which contained quicklime, so there was nothing new in such a mixture. Further, it had to be thrown into the water in order to catch fire, if indeed it did at all, and not onto the decks of boats as Leo's Tactica indicates. This theory also fails to account for the pots and jars of "Kallinikos' fire". The difficulties of this explanation are many, and the quicklime hypothesis does not seem plausible.

Another explanation has been offered by Lieutenant Colonel H. W. L. Hime of the British Army. In his earlier writings[26] this author accepts the quicklime hypothesis, but later (1915) he offers a new explanation. At the suggestion of Dr. Hodgkinson he proposes[27] that Kallinikos in his experimentation discovered calcium phosphide. He suggests that the substances necessary for the production, namely limestone or lime, bones and urine, were in common use by the alchemists. Hence the oleaginous material which was thrown would contain calcium phosphide. Colonel Hime explains the word σίφων (siphon) as a water pump. The oleaginous prepared fire was in the tube. By use of a pump, water was forced, ejecting the liquid and setting it on fire at the same time. Accordingly, he explains the word "*strepta*" as a flexible instrument or leathern hose of a water engine.

Thus this hypothesis accounts more or less satisfactorily for the ejection, that it could be kept secret, that it burned with noise and smoke. According to Colonel Hime, by the time of the fourth crusade there was much disinclination for war in the disintegrating empire, and there was no interest in this fire; as a matter of fact they had none to fight the heterogeneous crowd of the fourth crusade that followed Enrico Dandolo. The secret was lost. What became known in Western Europe from the first crusade as "Greek fire" is the old "Aeneas family tree type" of fire.

There are some difficulties in this explanation, of which one is the improbability of the discovery of calcium phosphide at such an early date. The other is that calcium phosphide, even if it is ground in proportions of ten per cent. with an incendiary mixture of the Aeneas family type, and mixed with water, does not catch fire even after ten minutes. Extensive experiments carried out by the author with several mixtures and calcium phosphide, show that gasoline and calcium phosphide will catch fire in thirty seconds to one minute from the time they have been mixed with water. If a small amount of oil is added to the gasoline, however, no fire occurs even after fifteen minutes. The Aeneas family type of incendiary mixture contains asphalt, sulfur, naphtha, charcoal, a gum, turpentine, etc., which easily cover up the phosphide and render the reaction with water very slow. Moreover, it is difficult to account for the use of "fire" with hand siphons. Finally, there is definite historical evidence that the Moslems were in possession of a liquid fire at the end of the eleventh century. They used this type of fire to bombard with Trebouchets (engines not depending on either tension or torsion, but on the sudden releasing of heavy weights) and also they employed the "tow-soaked-in-oil" type of incendiaries thrown by arbalests (crossbows). Again, if we assume the phosphide or quicklime hypothesis, we meet with incongruities for, according to Colonel Hime, the Moslems never obtained Kallinikos' secret.

This leads to consideration of the last explanation; that Kallinikos' secret was saltpeter. Kallinikos discovered that one of the saline salts which were known from ancient times as '*ανθη* (flowers), that is efflorescent salts, had combustible properties when mixed with

[24] VON LIPPMANN, "Beitrage zur Geschichte der Naturwissenschaften," p. 136; also "Entstehung und Aurbreitung der Alchemie," p. 478.

[25] BERTHELOT, "Les Compositions incendiaires dans l'antiquité et au moyen âge," Revue des Deux Mondes, **106**, 786 (1891).

[26] H. W. L. HIME, "Gun powder and ammunition, their origin and progress," London, **1904**.

[27] H. W. L. HIME, "Origin of artillery," London, **1915**.

the known incendiary materials. Berthelot[28] has written extensively on this explanation. As a summary of his views, it may be said that the Byzantines possessed in Kallinikos' fire the secret of saltpeter. Allowing for all exaggerations of the descriptions of the chroniclers, there is definite evidence that Kallinikos' fire was different from the Aeneas-Vegetius type. The secret of the fire was kept for four centuries, but finally leaked to the Moslems toward the end of the Crusades. The Moslems used it with effect against the Franks in 1189 to 1191 in Acre.[29] Again, Joinvilles describes its use by the Moslems in 1229. The evidence for such an explanation is controversial. According to Berthelot, the secret of Kallinikos' fire became known to the Occident at the same period as the translation of the "Liber Ignium" of Marcus Graecus from Arabic to Latin and during the time of Roger Bacon.

A great deal has been written on the controversial topic as to whether saltpeter was known to antiquity. The author, after an exhaustive examination of the literature,[30] is of the opinion that saltpeter was known at a much earlier date than the thirteenth century, although the propellant properties when mixed with charcoal and sulfur were not discovered until the Middle Ages. If we assume that Kallinikos did discover the principle of mixing saltpeter with combustible substances, the difficulties are not by any means removed. The "liquid fire" will have some such composition as sulfur, pitch, petroleum, "saltpeter," oils, and resins. Such mixture will account for the properties of smoke, roar, and incendiary properties, but how was it ejected or thrown? Berthelot states that it was ejected by metallic tubes, but does not make clear the mode of ejection. There is no reference to metallic tubes; whatever siphons were, they are represented as covered with copper. Zenghelis in his recent paper on the "Firearms of the Byzantines"[31] has a different view. He holds that the "prepared fire" of Kallinikos was a mixture analogous to gunpowder which was used for the shooting of incendiary projectiles upon the enemy. He explains, therefore, the smoke and roar by the change of the mixture into gases with projectile force. He uses a slightly different version[32] of Section 45 of Leo's Tactica which reads "the liquid fire which is sent with roar and smoke of the 'propyron'" which, according to Zenghelis, was a mixture exploding with smoke and propelling the incendiary projectile.

Further, Zenghelis explains the word "strepta" as a mechanism used to project the liquid fire, by referring to a book of "Poliorkitica" of Heron of Byzantium. There is a passage on attacking the forts, which reads as follows. "These stand upon the top steps and shoot fire in the face of the enemy with the hand-operated *strepta*, fire-arms (fire-throwing implements). And they frighten them so much, those that stand against the wall, that being unable to stand the stream of fire and the assault of battle they very quickly retire from the place. And the figures have been drawn."

Now Feldhaus[33] from the diagrams of the MS. gives the following picture of the "strepta" handworked "pyrobola," which, according to Zenghelis shows a gunner aiming the mechanism against the enemy. He assumes that the strepta was something of a trigger, that is, by turning (rather by friction of flint or tinder) fire was set to the saltpeter mixture, and by quick turning of the "strepta" and enclosing the gases the projectile was propelled. (See figures 1 and 2.)

Such an explanation would assign the discovery of the first type of gunpowder and the precursor of modern guns to Kallinikos and the Byzantines. In accordance with this hypothesis the information slowly leaked out, and this would account for the statement by Clemens Jager that a Jew named Typsiles brought the information to Augsburg. Naturally, to Berthold Swartz would be assigned the improvement and further development of firearms.

Brock[34] in his book on pyrotechnics, although he holds as probable the addition of saltpeter to the composition of the Byzantines, has a different theory as to the mode of ejection. He holds that a mixture of saltpeter, pitch, and sulfur, charged into a long tube sufficiently strong, and ignited, will burn, giving off dense smoke for a short time, when it appears to choke off momentarily; then follows a violent outburst which projects the burning mass to a considerable distance. This is repeated. According to this explanation, the ejection was operated on the principle of the Roman candle.

On the basis of the evidence available, the author of this paper believes as the most probable theory, that Kallinikos discovered that the addition of saltpeter to the known incendiary mixtures increased their combustible powers. The mode of ejection may be pictured somewhat as follows. Assume a man called "siphonator" on the bow of a fast boat holding a tube covered with copper on the outside. The tube leads to a pump such as has been described by Heron of Alexandria[35] and Apollodoros[36] called siphon and used to put out fires (second century A.D.). The pump is connected also by a hose to a tub which contains the semiliquid composition. When the boat is a few feet from the enemy's ship, the pump goes into action, while the siphonator directs the siphon, and the liquid is ignited as it is shot. The method of igniting should not

[28] BERTHELOT, "Les compositions incendiaires," p. 786.
[29] OMAN, "History of the art of war in the middle ages," Vol. I, p. 186, London, **1924.**
[30] BERTHELOT, "Les compositions incendiaires," p. 806; VON LIPPMANN, "Entstehung und Aurbreitung der Alchemie," Berlin, **1911,** p. 478; HIME, "The origin of artillery"; HERODOTUS, II, 86; PLINY, "Natural History," Book II, ch. 96; Book XXXVI, ch. 17; Dioscorides, L. V. 85; LUCIAN, "Tragopodagra," 155–70.
[31] ZENGHELIS, "*Περὶ του υγροῦ πυρὸς καν τῶν πυροβόλων 'όπλων τῶν βυζαντίνων.*" *'Απὸτ ὴν Ζωὴν καὶ τὴν Φυσιν.*" p. 93, Athens, **1931.**
[32] DIELS, "Antike Technik," Teubner, **1914,** p. 98.
[33] FELDHAUS, "Die Technik," p. 303, Berlin, **1914.**
[34] BROCK, "Pyrotechnics: The history and art of firework making," London, **1922.**
[35] HERONIS, "Veterum Mathematicum," 152–3; Paris, **1693.**
[36] APOLLODOROS, "*Πολιορκητικά*," Veterum Mathematicum, p. 32, Paris, **1693.**

be difficult to account for, as in Leo's Tactica mention is made of tinder and wicks. Kallinikos' mechanism must have been such that the fire would be handled safely; otherwise we cannot account for its continued use.

Now for the hand-siphons and "strepta". The hand-siphons can be described as squirts, operated by hand, shooting the liquid incendiary, and may rightly be regarded as the precursors of modern firearms. The "strepta" are similarly mechanisms of improved type, and closer to modern firearms. The description denotes a mechanism to eject prepared fire, and from the name is associated with something turning. If one is not disposed to accept Zenghelis' explanation that they were crude hand guns, based on projecting a charge by force of explosion, the only possible explanation remains that they were operated by turning, and ejecting a prepared liquid incendiary igniting it at the same time.

No matter what explanation we are willing to take, there is sufficient evidence that the Byzantines made extensive use of chemical warfare in the Middle Ages, and to this use may be ascribed the continuation of the empire for several centuries. There is also sufficient evidence that the Byzantines developed and used hand grenades and also the precursors of modern firearms. Kallinikos, then, may be regarded as the "pyrochemist" of the Middle Ages.

The METHODS *of* QUANTITATIVE CHEMICAL ANALYSIS

M. G. MELLON

Purdue University, Lafayette, Indiana

AND

D. R. MELLON

City Chemist, Youngstown, Ohio

THE general problem of making a chemical analysis quantitatively is to determine the amount of one or more constituents in a given sample. This determination is accomplished by measuring, directly or indirectly, some property of the desired constituent, frequently after a preliminary separation or purification has been effected.

In the last century and a half many methods of analysis have been devised, including a wide variety of procedures. In attempting to provide some classification for these methods it has long been the practice of analytical writers to base their arrangement upon the technic involved in the process. Thus, one finds today almost universal adoption of the terms gravimetric and volumetric to designate methods in which measurements are made "by weight" or "by volume," respectively.

Blasdale's scheme (*2*) has seemed to the writers the best of the present classifications based upon technic, being sufficiently comprehensive to include gravimetric, volumetric, electrolytic, gasometric, and physicochemical processes, and providing for certain subdivisions in these classes. Thus his gravimetric group comprises gas-evolution, gravimetric precipitation, solution and extraction, and partition processes. In contrast to the latter treatment, various authors, following the practice Fort (*5*) attributed to many scientists, have left out of their gravimetric division all procedures which do not involve the process of precipitation as a means of separation. Those eliminated have been conveniently disregarded, as far as classification is concerned. In spite of its merits, however, Blasdale's arrangement is not adequate (*a*) in providing for various methods of measurement, such as those based upon the volume of a precipitate, and (*b*) in distinguishing between methods of separation and measurement.

A commendable effort was made by Fales (*4*) to use a different classification. He considered kinds of methods from the viewpoint of the "fundamental principle" involved. Examples of such principles are neutralization, solubility product, and oxidation-reduction. While this scheme is admirable as far as it goes,

the writers have been unable to extend the idea satisfactorily to include the many different methods now known.

The chief merit of any classification of procedures is to bring into an orderly arrangement for study and use the mass of facts relating to the processes. The particular scheme adopted is not a matter of great importance as long as it serves to provide an intelligent and efficient comprehension of the general principles and operations involved in the methods. It is desirable, of course, to have the basis broad enough to include all methods.

As a result of their experience with the literature of quantitative chemical analysis, the writers have formulated an outline which suggests a somewhat different viewpoint from those mentioned above. In it an attempt has been made to include all the most important operations, substantially in the order in which they are encountered by an individual beginning the study of general methods in quantitative analysis.

The outline has been designed to cover not only kinds of methods, from the standpoint of the technic involved, but also the arrangement of material in any given procedure. Since the topics relate primarily to the general operations employed in handling the sample and the desired constituent, these two items become the outstanding points of interest in the present treatment.

I. THE SAMPLE

To make an analysis there must first be a sample. In handling it several general operations are usually encountered, as indicated below. These are likely to be least in number in the application of certain automatic methods to continuous processes.

1. *Selection and Preparation.*—Obviously, one must select his sample and then subject it to whatever preparation is necessary to produce reliable analytical data. What is necessary in this direction varies more or less, depending upon the general nature of the material to be sampled and upon its physical state. As the general problem of selecting and preparing samples has been adequately presented in various publications, no further attention will be given to it here.

2. *Measurement.*—Whenever a sample is to be handled quantitatively, a measured portion is necessary, except in certain physicochemical procedures, such as refractometry. The operation of measurement is usually accomplished by one of the two following means:

(*a*) *By Mass.*—In this case the measurement is made with an analytical balance and weights, the construction, testing, adjusting, and use of which are discussed in various sources. This is the customary method for handling solids and frequently also material in the liquid state.

(*b*) *By Volume.*—For materials in the liquid or gaseous state it is frequently most advantageous to measure the sample by volume, using familiar volumetric ware, including the different kinds of flasks, burets, and pipets. The testing and use of this apparatus are fully presented in a number of texts.

It is assumed that the presentation of material under the previous two headings will be adequate for the application of these means of measurement not only to handling the sample but also to any products obtained therefrom in the course of the analysis.

3. *Treatment.*—In many cases one may proceed with the determination as soon as the sample is measured, no preliminary treatment being necessary. Examples are the determination of moisture in coal and of nitrogen in milk. More frequently, however, it is necessary to subject the sample to some kind of treatment in order to get it in a condition suitable for subsequent operations. Some of the treatments commonly encountered are mentioned below.

(*a*) *Drying or Ignition.*—Occasionally it is desirable or necessary to heat the sample before starting the analysis. For example, preliminary ignition of iron ore samples is recommended to remove organic matter which might interfere later in a permanganate titration.

(*b*) *Concentration.*—Some samples, such as waters of low mineral content, contain so little of the constituent sought that it is advantageous to concentrate them to obtain larger amounts with which to work.

(*c*) *Fusion.*—Many substances, particularly rocks and ores, cannot be dissolved satisfactorily until fused with some compound or mixture. The material selected depends upon the nature of the sample, but most often it is acidic or basic in character, depending upon whether the substance to be fused is respectively basic or acidic.

(*d*) *Dissolution.*—Whether fused or not, the majority of solid samples must be brought into solution, since, under these conditions, the operations and transformation necessary in many determinations are accomplished best. The solvent selected depends principally upon the nature of the sample and the disposition to be made of the solution. In the Kjeldahl method for nitrogen, digestion of the sample with concentrated sulfuric acid serves not only to dissolve a variety of nitrogen-bearing materials, but also to convert the nitrogen to a compound from which it may be separated readily.

The operation of dissolution is necessary not only for the sample at this point, but also, later in the determination, for various separated products before proceeding with their measurement.

(*e*) *Adjustment of Conditions.*—In some cases the conditions prevailing when a sample is dissolved are not suitable for the next operation, or one separation may leave the system unfit to proceed with the next until some readjustment is made. Elements with more than one valence state, for example, may have to be treated with some reagent. Thus it is necessary to complete the oxidation or reduction of iron dissolved from an ore, depending upon whether the element is respectively to be precipitated as the hydrous oxide or titrated with an oxidant. A second example is the formation of complexes prior to certain electrolytic separations.

Mention might be made at this point of the occasional

problem of keeping the solution in a given condition until the next operation can be performed.

II. THE DESIRED CONSTITUENT

One's next concern is to ascertain what portion of the sample consists of the constituent sought. The procedure necessary to accomplish this end may be very simple, as in the determination of moisture in coal; or it may require considerable time and manipulation, as in the estimation of the alkali elements in a silicate rock.

In many cases samples are of such a nature that, either with or without one or more of the above-mentioned preliminary treatments, one may proceed at once with the determination. Vinegar, for example, may be titrated as soon as the sample is measured and diluted. More often, however, more or less work must be done to accomplish a suitable separation of the desired constituent from interfering substances before its amount can be ascertained. There are, therefore, often two parts to the problem of determining the desired constituent—the separation and the actual measurement.

It is the general practice in analytical works to give the details of the procedure in the order in which the operations are carried out without any emphasis on the separation as such. While this may be desirable in writing directions for routine commercial laboratories, the writers are convinced that textbooks might well emphasize more this part of the procedure. In many cases the process of separation is much more difficult and involved than that of measurement of the separated product.

1. *Separation.*—In making quantitative separations the desired constituent, either by itself or associated with certain other elements, is isolated by removing it or the interfering constituents from the system. The constituent separated, the form in which it is handled, and the method of accomplishing the isolation depend upon the properties of the various constituents composing the sample. Sometimes two or more kinds of separations may be used in a given determination.

The most widely used methods of effecting separation are considered below. Of the different items bearing upon each method, the following are probably of most importance: the nature of the process, including the means of separation employed; the nature and disposal of the products; and the applications and merits of the method. The present object is primarily to direct attention to the distinctive principles involved. In most cases treatises present the details of procedures and their application.

In attempting to subdivide methods of separation on the basis of physical and chemical properties of constituents one encounters difficulties. As a broad basis of differentiation, however, it seems legitimate to speak of mechanical and chemical methods. Mechanical is used to refer to separations made without changing the state of, or bringing about a reaction with, the constitutents of the sample. Examples of this type are the separation by filtration of suspended matter in gases and liquids, the manual or magnetic removal of constituents from samples, and the sieving analyses of cement. Chemical is used to refer to processes involving, for the liberation of a constituent, some transformation, such as a change of state, or a reaction effected by some chemical reagent or the electric current. The latter group constitutes the great majority of separations. The more important of these procedures will now be considered.

a. Volatilization.—The alchemists' calcinations, sublimations, and distillations indicated a means which analysts early learned to apply to make many separations based upon the different volatilities of different substances. To carry out these processes requires that the temperature of the sample be changed in such a way as to bring about the desired vapor pressures of the components.

This method is usually applied to systems in the solid or liquid state. Blasdale's gas-evolution methods have this means of separation as their distinctive feature. As he has pointed out, there is involved a phase transformation from a solid or liquid to a gas. In connection with the application of the process, several items of interest may be noted.

The reactions of different substances are so different that one finds interesting variations in the method of evolution used. In many cases, such as the determination of the water of crystallization in barium chloride dihydrate or of mercury in organic compounds, the sample is merely heated at a suitable temperature. Boiling solutions to remove substances such as carbon dioxide or bromine are additional examples. The general processes of sublimation and distillation belong in this division.

There are also many cases in which heating alone does not suffice. It is necessary to add a reagent of some kind, generally accompanied or followed by more or less heating. The use of a suitable tungstate flux enables one to evolve all the water from cupric sulfate pentahydrate without liberating any oxides of sulfur. In the familiar method for determining carbon dioxide in a carbonate rock a strong acid is added, the sample heated, and a current of carbon dioxide-free air sweeps the evolved gas along to be absorbed. The reagent used may be included as a part of the system weighed, as with the tungstate mentioned above, or with the use of an alkalimeter to determine carbon dioxide. There may be mentioned also the use of a volatile reagent which leaves a fixed and definite product on heating with the sample. Perhaps the simplest way to standardize a solution of magnesium chloride is to evaporate a measured volume to dryness with an excess of sulfuric acid and weigh the residue of magnesium sulfate.

In the process of evolution the constituent liberated may react in one of two ways. For various substances there is merely a change of state, a sufficient elevation of temperature serving to increase their vapor pressure to a point where they may be separated from the remainder of the system. Such is the case in distilla-

tions. In contrast to this transformation, the other type of reaction represents a change of composition. Thus, in steel analysis, one separates the carbon by burning it to carbon dioxide.

The details of the procedure vary for disposing of the products. What is liberated may be the interfering substance or the desired constituent, the latter being either by itself or accompanied by more or less of one or more interfering substances. One may simply disregard the eliminated constituent, taking precautions only to insure its complete but sole removal. This is the expected thing if it is the interfering substance; but it is practical also where the measurement of the residue will give by difference the amount of the desired constituent. In determining moisture in coal, for example, one weighs the residue after volatilizing the water. The alternative to this procedure is to collect the desired constituent, resorting if necessary to purification, generally by another means of separation, in order to get the desired constituent in a condition suitable for measurement. The Dumas method for determining nitrogen is an example.

For some systems in the gaseous state one should be able, theoretically, to separate the components by what amounts to a reversal of the process of volatilization, that is, by fractional condensation (7). In practice, however, the manipulative difficulties are such that analysts generally prefer to cool the whole sample to a low temperature and then to make the required separations by fractional distillation (8).

b. Precipitation.—The term, precipitation, as it is generally used in analytical chemistry, refers to the process in which an insoluble compound is formed in a solution of the sample. Considered more broadly, however, it generally involves the separation of a solid phase from a liquid phase. There is included, then, such examples as the precipitation of selenium by reduction of the insoluble element from one of its soluble compounds.

The solid phase is formed most frequently to contain the desired constituent; but there are many instances in which the interfering constituent is removed from the system in this manner, leaving behind the desired constituent which may then be measured.

As already mentioned, some analytical authors have limited gravimetric methods to those involving a separation of the desired constituent in the form of an insoluble compound. The present writers are attempting, of course, to promote a different point of view.

The general subject of precipitation has received more attention in analytical works than any other method of separation, but it has been treated primarily as a part of gravimetric methods of determination, rather than as a method of separation. In view of this previous attention, and since the nature of the process bears no relation to what one calls it, the present purpose will be fulfilled by mentioning the following important items as being associated with precipitation: solubility product principle, common and diverse ion effects, colloidal phenomena and adsorption, the nature and purity of precipitates, filtration and washing.

c. Electrochemical reduction (oxidation).—A number of separations can be made electrochemically by means of electronic reactions. Two ways of accomplishing these separations may be recognized.

a'. With current (Electrodeposition).—In the majority of electrochemical separations the essential reaction is effected by means of a direct current passed through a solution containing in ionic form the desired constituent. In the case of cations the process consists in reduction through restoration of the lost electrons, the separation of copper being the most familiar example. The much less useful process of oxidation involves removal of excess electrons, such as occurs in the separation of the halogens on a silver plated electrode.

The term electrolytic is used most often in connection with such methods. It usually has reference, however, to the whole procedure rather than merely the method of separation.

The proposed classification does not change the present situation for separations that can be made through control of the voltage or the composition of the electrolyte.

b'. Without current (Displacement).—There are a few important electro-chemical separations based upon use of the relations of the elements in the E.M.F. series. In determining copper in an ore, for example, a strip of aluminum may be placed in the solution containing the copper ions, whereupon the copper is deposited as such on the aluminum sheet. The deposit may then be dissolved and its amount suitably measured.

d. Extraction.—In various fields of analysis extensive use is made of the selective action of different reagents toward the substances constituting the sample. Such a method enables one, by means of the appropriate reagent, to isolate from the sample either the desired or interfering constituent. Through the successive use of different reagents it is possible in various cases to remove several constituents, one after the other. Whenever it is practical, the sample is treated directly with the reagent. Sometimes it is necessary to make certain transformations in order to secure products of the desired solubility relationships.

In the present treatment the term extraction is used to include methods which, at first thought, might seem to be based upon quite different principles. Thus one finds constituents being separated by solution, absorption, partition, adsorption, dialysis, reactions like that between oxygen and phosphorus, and probably others. The mechanism operative in these cases undoubtedly differs from one to the other, but for the present purpose no distinction will be made. From the analyst's viewpoint, as long as desirable results are obtained, it makes little difference, for example, whether oxygen is separated from air by means of alkaline pyrogallol or phosphorus. Whatever form this type of separation takes, it seems probable that the mecha-

nism involved is generally that of solution or some kind of compound formation.

It is convenient in considering some applications of this method to subdivide the material on the basis of the physical state of the sample to be treated.

Gases are usually analyzed by the so-called methods of gas analysis. Many separations of two or more gaseous constituents are made by bringing the sample successively into contact with different absorbents, suitably selected for removing the gases sought. Such absorbents are usually spoken of as solvents. Special gas analysis apparatus has been designed for their use. Other kinds of reactions are used in this field, such as adsorption and the reaction between oxygen and phosphorus.

Extraction of solids is generally made with liquid solvents, although the use of certain gases is conceivable. Leaching with water and extractions with alcohol or ether are familiar processes. A variety of extractors, such as the Soxhlet, Wiley, and Bailey-Walker types, have been proposed. Solution-extraction is the term applied by Blasdale to determinations including this kind of separation. In a sense, the process of solution may be considered as the opposite of precipitation.

Certain substances in liquid solution may be removed by shaking with a second solvent in which they are more soluble and which is immiscible with the first solvent. The substances not extracted obviously must be practically insoluble in the second solvent. This is the basis of Blasdale's partition methods. They depend upon the distribution ratio of the substances for the solvents concerned.

2. *Measurement.*—After making any necessary separations, ascertaining the amount of the desired constituent constitutes the remaining general operation. To designate this process the term measurement is suggested. Through long usage the term determination has come to be used in a more or less general sense to refer to a method as a whole. Thus, when authors write about the volumetric determination of calcium, they include the treatment of the sample, the separation of the calcium as the oxalate, the solution of the precipitate and the titration of the oxalate ion.

In this section it is the writers' intention to outline the kinds of methods most commonly used for measuring constituents quantitatively. It is obvious from the emphasis given above to methods of separation that at this point there must be some divergence from current practice in referring to methods. For example, in the thiosulfate method for determining copper in an ore, which is given as a volumetric process, the major part of the procedure is a separation.

Although there has never been agreement among analysts regarding classification of methods, practice has been quite general in using at least part of the terms gravimetric, volumetric, electrolytic, gasometric, and physicochemical. In suggesting some changes in this usage the writers have in mind two objectives: first, to differentiate in any given procedure between methods of separation and measurement; and second, to provide for various procedures which do not seem to fit in any current scheme. Individuals who have not been disturbed by deficiencies of classification have resorted, in the latter case, to the device of providing a special or miscellaneous class for the non-conformers.

A detailed consideration of each method should include at least the following points: the nature or principle of the method; the different means available for making the measurement; including the procedure in each case; the application of the method; and the merits both of the method as a whole and of the different variations of it. The present objective is merely to outline the kinds of methods according to their distinctive principles.

It has seemed advantageous to base the proposed system upon the measurement of different properties. The general outline of the scheme follows.

(*a*) *Specific Property Methods.*—In many cases where the desired constituent can be suitably isolated, the measurement of some property of it makes possible an estimation of the amount of the constituent. This measurement is made either on the constituent as such or on a compound of it of known composition, from which the necessary calculations can be made. Although properties suitable for such measurement are not numerous, many methods are based upon those available. The material below is presented under the headings of the specific property concerned.

(*a'*) *Mass.*—It is probably safe to state that the analytical estimation of substances is most often accomplished by measuring their masses. Two variations, each widely used, may be recognized in the means employed for the measurement.

(*a''*) *Directly.*—Ever since the analytical balance became available it has been the analyst's most useful instrument for measuring masses, not only of samples but also of constituents obtained therefrom. The process of weighing is so well known that it need only be mentioned. Determinations of mass by difference are included here.

The term gravimetric has enjoyed wide usage in connection with methods based upon these measurements made "by weight," and its continued use seems desirable. Gravimetry would include all such methods. Attention is directed, however, to the fact that in this scheme these terms refer only to the method of measuring constituents. Nothing is implied about the method used to effect any necessary separations prior to the measurement. Obviously, this means abandoning certain designations as they are more or less commonly used, such as electrolytic, gas-evolution, and solution and extraction methods, since they properly refer to methods of separation which bear no essential connection to the method used subsequently to measure the constituent separated. Thus, the ordinary "electrolytic determination" of copper consists of a gravimetric measurement of the electrochemically separated metal.

(*b''*) *Indirectly.*—Although there seems to be a cer-

tain simplicity, and consequent attractiveness, to methods in which a direct measurement is made on the desired constituent, frequently it is more advantageous to resort to an indirect measurement. This is done most often, probably, by determining the amount of some substance which is equivalent to the desired constituent. Such is the basis for the commercially popular "volumetric" methods. In them actually one bases the calculation upon the amount of active reagent in the standard solution found to be equivalent to the desired constituent.

To designate this class of methods it is proposed that the term titrimetric be used instead of the older term volumetric which is reserved for use in a later section. The term titrimetric has the advantage both of indicating that the method is one employing titration and of providing for titration "by weight" and "by volume". Titrimetry would include all methods based on measurement by titration.

The two familiar electrometric methods, potentiometric and conductometric, play a dual rôle. In titrimetric work they represent types of methods for determining endpoints, while in physicochemical determinations they furnish data for calculating concentrations.

(*b'*) *Volume.*—Next to mass one thinks of volume as the quantity most likely to be susceptible to measurement for quantitative work. There are a number of methods based upon this property. To designate them it seems appropriate here to use the term volumetric, in spite of possible confusion with titrimetric methods. Volumetry (or volumenometry) would serve as the general term.

Three currently used applications of volumetric methods may be mentioned: first, in gas analysis, where the measurement of gaseous constituents is made by volume at constant temperature and pressure; second, in the A.S.T.M. method for water in petroleum products, the volume is measured after suitable distillation; and third, in handling precipitates which have been centrifuged in special containers which provide for the measurement of the volume of the deposit. Possibly these three types might be indicated respectively by the terms gas-volumetric, liquid-volumetric, and solid-volumetric.

(*c'*) *Pressure.*—Previous outlines have made no provision for cases in which pressure is the quantity measured. While such methods are relatively uncommon, they are of sufficient interest to justify consideration. The Bone and Wheeler apparatus for analyzing gases at constant volume and temperature illustrates the application of the method on a macro-basis. In micro-determinations particularly, the Van Slyke apparatus is stated to give more reliable results than the volumetric method. The terms manometric and manometry seem appropriate for such procedures.

(*d'*) *Heat of Reaction. Temperature.*—Another nonconforming, but nevertheless significant, type of method is that based upon the measurement of temperatures. Essentially this amounts in most practical cases to a measurement of the heat of a reaction, such as the B.t.u. value of coal and the calorific value of foods. It should be possible, of course, to make gas analyses by maintaining constant volume and pressure and varying the temperature. To designate such methods the term thermometric is suggested. The logical general term, thermometry, is used in physics in a somewhat different sense.

(*b*) *Systemic Property Methods.*—In a large group of methods the determination depends finally upon the measurement of some property of a system containing the desired constituent. This property, to be analytically valuable, must be such that the magnitude of the quantity measured bears a known relationship to the amount of the constituent present. In many cases this involves the construction, from systems of known composition, of curves coördinating composition and the quantity measured.

This group contains the methods which have been designated by various writers as physicochemical procedures. Since they are generally familiar, and since no changes are suggested, it is sufficient for the present purpose merely to give the present main subdivisions of the group, as indicated below.

- (*a*) Specific gravity and density methods (densimetry)
- (*b*) Colligative property methods (colligimetry)
  - (*a*) Freezing point (cryoscopic; cryometry)
  - (*b*) Boiling point (ebullioscopic; ebulliometry)
  - (*c*) Vapor pressure (vaporoscopic (?); vaporimetry)
- (*c*) Optico-chemical methods (opticometry)
  - (*a*) Refractive index (refractometric; refractometry)
  - (*b*) Optical rotation (polarimetric; polarimetry)
  - (*c*) Spectral lines (spectrometric; spectrometry)
  - (*d*) Color (colorimetric; colorimetry)
  - (*e*) Spectral absorption (spectrophotometric; spectrophotometry)
  - (*f*) Turbidity (nephelometric; nephelometry)
  - (*g*) X-ray reflection (radiometric; radiometry)
- (*d*) Electrochemical methods (electrometry)
  - (*a*) Electrode potential (potentiometric; potentiometry)
  - (*b*) Electrical conductivity (conductometric; conductometry)
  - (*c*) Polarization (polarisimetric; polarisimetry)
- (*e*) Thermochemical methods (thermalimetry)
  - (*a*) Thermal conductivity (thermal conductometry)
  - (*b*) Phase equilibria (phasimetry)
- (*f*) Reaction rate methods (*6*) (speedometric; speedometry)

Nomenclature.—Most individuals rightly resent the introduction of new terms in technical fields already overburdened, especially in subjects as long established historically as analytical chemistry. It is with some hesitancy, therefore, that various changes are recommended for quantitative analysis.

Suggestions for designating several methods of separation or measurement have already been given, with reasons therefor. There remains what seems a desirable objective, namely the proposal of names for methods as a whole which will indicate both the process of separation and of measurement. In view of the lack of suitable short words, the most feasible alternative is the combination of terms already applied

to the separate processes. This still leaves the question what to put first, the term for the separation or for the measurement. The order of performance would suggest the former; but in view of some usage in the latter direction (*2*, *9*) this alternative seems preferable. On this basis names such as the following are representative: gravimetric-electrodeposition, manometric-volatilization, titrimetric precipitation,* volumetric-extraction, specific gravity-volatilization, and similar combinations. Use of the first word only would imply that no separation is involved, as in the titrimetric determination of the acidity of vinegar. In the puzzling case where two or more kinds of separations are encountered in one procedure, such as the method employing steam distillation, extraction, and precipitation in separating diphenylamine, presumably the one deemed the most prominent would be named.

It seems wise to continue terms such as rock, fuel, water, and gas analysis as referring to classes of materials. However, certain words currently used might be abandoned. As examples, the term gasometric, at least in its present usage, implies corresponding terms applicable to liquids and solids. Also it gives no indication of the different kinds of measurement that may be used for gases. Electroanalysis is unique only in the method of separation used, so that electrodeposition or electrolytic separation seems preferable.

Form for Individual Procedures.—Although the foregoing discussion has been devoted to methods as a whole, it is believed the general idea can be used effectively in arranging the material for individual procedures. For this application the writers suggest the following separate divisions of the detailed directions: (1) a list of any special reagents and/or apparatus required, with directions for their preparation, following the practice of the A. O. A. C. methods (*1*); (2) material dealing with the sample, its measurement, and treatment; (3) material relating to any separations necessary to make possible a measurement of the desired constituent; (4) material dealing with the measurement, including the calculation of results; and (5) notes regarding any special points needing explanation.

Individual preference here is a very significant factor. The suggested arrangement is based upon the belief that operating directions should be as brief as possible and yet be effective. A separate presentation would be made of the principle of the method, its merits and applications, the chemistry involved, and similar significant items.

* Precipitation here refers to the method of separating the constituent to be titrated and not to the reaction involved in the titration.

SUMMARY

There is presented in outline form a logical arrangement of fundamental topics for a general course in quantitative chemical analysis in which emphasis is directed particularly to the sample and to the separation and measurement of the desired constituent. For this scheme the following are suggested as definite points of merit.

1. Distinction is made between operations involved in handling the sample as such and in handling the desired constituent.

2. The technic of the two most used methods of measurement, gravimetric, and volumetric, is brought in together early in the treatment. This is an advantage to beginning students whether they start with titrimetric or gravimetric methods, since they weigh in either case.

3. In all procedures distinction is made between the part of the process which relates to any necessary separation of the desired constituent and the part dealing with its measurement.

4. The classification seems to be sufficiently comprehensive to provide for present methods. In addition, it is believed any new types of methods of separation or measurement may be fitted in logically.

5. The nomenclature suggested gives a more definite specification of the methods of separation (if any) and of measurement used in any given procedure.

6. A form is proposed for the directions for individual determinations which emphasizes more definitely the portions dealing with the sample and with the separation and measurement of the desired constituent.

LITERATURE CITED

(1) "Official and tentative methods of analysis," Association of Official Agricultural Chemists, Washington, D. C., 3rd ed., 1930.
(2) BLASDALE, "Fundamentals of quantitative analysis," D. Van Nostrand Co., Inc., New York City, 1928.
(3) COOK, *Ind. Eng. Chem., Anal. Ed.*, **7**, 250 (1935).
(4) FALES, "Inorganic quantitative analysis," The Century Co., New York City, 1925.
(5) FORT, "The book of the damned," Boni and Liveright, New York City, 1919.
(6) HASS AND WEBER, *Ind. Eng. Chem., Anal. Ed.*, **7**, 231 (1935).
(7) LUNGE-AMBLER, "Technical gas analysis," D. Van Nostrand Co., Inc., New York City, 1934.
(8) PODBIELNIAK, *Ind. Eng. Chem., Anal. Ed.*, **3**, 177 (1931).
(9) WARE, "Analytical chemistry," John Wiley & Sons, Inc., New York City, 1931.

The life and soul of science is its practical application; and just as the great advances in mathematics have been made through the desire of discovering the solution of problems which were of a highly practical kind in mathematical science, so in physical science many of the greatest advances that have been made from the beginning of the world to the present time have been made in the earnest desire to turn the knowledge of the properties of matter to some purpose useful to mankind.—LORD KELVIN

SOME *of* MENDELÉEFF'S PERSONAL CHARACTERISTICS*

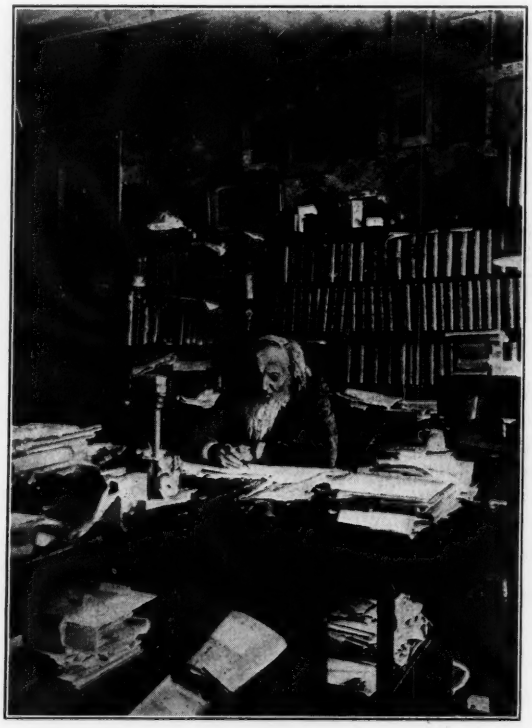
WILLIAM R. WINICOV

Northeast High School, Philadelphia, Pennsylvania

CARELESSNESS about conventionalities and then the sudden realization of his ignorance in these matters, coupled with his terrific temper or temperament, were dominant characteristics in the personality of Mendeléeff. They showed themselves most pointedly in his relations with people—the further removed they were from him with respect to their life's interests, the more piquant, peculiar, and bizarre was the result when he came in contact with them. It must be pointed out, however, that mere difference of class, whether intellectual, economic, or otherwise, played no part in this. Dmitri Ivanovitch felt perfectly at home in the company of peasants, because they had a common interest in farming and farm problems; with working men he could discuss technical questions, with business men economic problems. But when he came face to face with the reporter of a cheap newspaper he was completely at sea... It was a strange profession to him, one he did not understand, and he was somehow frightened by it.

The following incidents are quite characteristic.

The employes of the Bureau of Weights and Measures, of which Mendeléeff was the Director, liked to pass their idle moments in the main office. Here one could look through the newspaper, hear the latest news of the Bureau, the center of which was "he," Dmitri Ivanovitch. Besides, the office served as an observation post, for from its windows one could see the driveway and the paved path leading to the gate and out into the street. Both of these were the center of attraction when someone was arriving, and aroused quite a bit of speculation. Who is he? Will he stay long? And in what condition will he leave? There was much merriment when the visitor left hastily and obviously upset; that meant that Dmitri Ivanovitch had "let him have it." But, on the other hand, everyone felt certain that "he" was upset, too, and would soon send for the "Valerian Drops," a nickname applied to the kindly and lovable V. D. Sapózshnikov and Miss Ozarovskaya, who were able to calm the nerves of their beloved chief. For that reason, whenever they saw the bareheaded servant, Mikhailo, nicknamed "The Fish Hook," running across the driveway in the direction of the main office, the question uppermost in everyone's mind suddenly became, "Who will be hooked now?" This almost childish interest with which even the old men of the staff looked out of the window shows clearly how charged the entire atmosphere of the Bureau was with "his" presence. Their conversations, even those of the most serious character, often began with "Now yesterday I said to him," or "But he does not want this," or "He thinks that....." The pronoun "he" was declined back and forth constantly and unconsciously, because the image of Mendeléeff was always uppermost in their minds.



D. I. MENDELÉEF IN HIS STUDY

One day the "Fish Hook" caught Miss Ozarovskaya in the office. She followed the servant, wondering what the chief might need her for. There was no proofreading to be done. Soon the mystery was cleared up. She was to write a letter to some Spanish chemist who had

* Based on Reminiscences by Olga E. Ozarovskaya, U. S. S. R. Press "Federatsia," Moscow, 1929.

prepared a new iodine compound, which, in Mendeléeff's opinion, necessitated the re-examination of the atomic weight of that element. Dmitri Ivanovitch told her what he wanted to say, but the formulation of his exact thoughts in a foreign tongue had the girl puzzled for a while; she had to write it down first, and then go over it, making the necessary corrections.

"Tell me, please, how are you going to write it?" Mendeléeff asked.

But that she could not do until after she had put his thoughts on paper and found the appropriate phrases. Knowing him as she did, she said nothing and continued writing.

"PLEASE TELL ME FIRST!" he began to thunder, and then suddenly burst into laughter. "Uh, what independence!" he said good naturedly. "Oh well, never mind, I like them that way. I am that way myself. Now how did you write it, please?"

She had hardly finished when the door bell rang, and the voice of a reporter, asking to be announced, was heard in the corridor. Dmitri Ivanovitch rose to find out what the commotion was all about, and the battle began at once.

"Who is that?" he inquired. Then he saw the stranger. "Your card!"

"A reporter of the newspaper 'Peterbourgski Listok,' your excellency."

"Dmitri Ivanovitch," the scientist corrected his interviewer. "Your card... I don't know who you are... Well, what do you want? I am busy."

"I... Your excellen..."

"Dmitri Ivanovitch."

"I have come, your excellen..."

"A-A-A, DMITRI IVANOVITCH!!"

"Dmitri Ivanovitch," the reporter finally understood, "I shall deprive you of only a few minutes..."

"Hurry, only hurry!" shouted the scientist. "We are busy...writing a letter, see? Well, what is it?"

By that time the enemy had already entrenched himself in a chair.

"If you please," he began, "allow me to ask, what is your opinion of radio?"

"O-o-o-o?! Oh Lord!"

Mendeléeff bent forward, somewhat on his left side, and groaned for what seemed a very long time, shaking his head all the time and repeating from time to time, "Oh Lord." Then he turned to the visitor.

"Now how am I going to talk to you?" he began in a high-pitched, plaintive voice. "Why, you probably can't understand anything. How, then, am I going to talk to you about radio? Oh well, here you may have my article on the subject—if you will understand it, then thank heaven. One thing I will tell you, though," he suddenly became quite amiable. "My friend, Ramsay, whose portrait you see standing here, he, too, has, been attracted by the subject. It is a rather interesting problem, but an obscure one; much is being said about it, but little is actually known. Well, is that all? What else? Hurry! Time, time is passing."

"Why, how did you come to think of the periodic system, Dmitri Ivanovitch?"

Again groans, shaking of the head, sighs, and laughter, "Kh, kh, kh."

"Not the way you do it, brother, " he finally burst forth emphatically. "Not so much per line! Oh no! Not the way you are doing it! I had been thinking about it for perhaps twenty years, and you must imagine—pshaw, sat down, and all of a sudden, hm, five kopecks per line, and presto! It's done! Oh no! Not that way. Well, is that all? I have no time. We are busy... writing a letter..."

"What kind of a letter?"

"O-o-o-oh!?"

Mendeléeff stopped stock still, inhaling deeply. There followed a pause when dead silence reigned in the room. Then he shouted as loudly as he could, "A LOVE LETTER!"

The enemy was beaten and hastened to retreat, while the big-hearted victor voluntarily explained that the letter was being written to so-and-so in relation to such-and-such a matter.

However, another reporter of a large newspaper did not fare so well. He came on the occasion of some kind of Mendeléefian anniversary; there were many of these in his later years, celebrations in honor of his many and varied activities. Dmitri Ivanovitch did not like them, and either left the city on these days or expressed such emphatic opposition to them that no one dared send him their congratulations, much less coming to congratulate him personally.

Well, on one such occasion a distinguished member of the staff of one of the metropolitan newspapers donned a frock coat and appeared before the old scientist with his felicitations.

Mendeléeff flew into a rage and began to thunder that he would not waste his time on such nonsense. But then he apparently began to feel sorry for his visitor and softened a bit.

"Well," he said, "since you are already here, sit down. Let's chat a while."

The newspaperman accepted the invitation and asked, "How do you, professor, look upon higher education?"

Dmitri Ivanovitch looked at him.

"How old are you?" he inquired.

"Thirty-five."

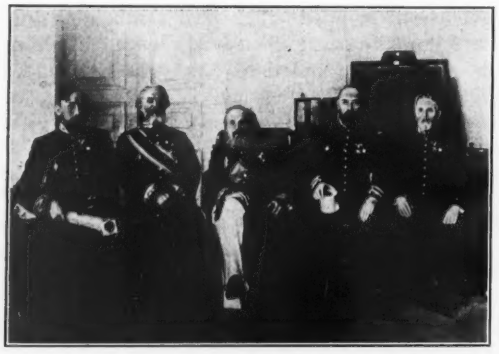
"Well, in my opinion you are twelve, and with a twelve-year-old I cannot discuss such matters. Excuse me..."

The interview was at an end.

But Dmitri Ivanovitch did celebrate, or, rather, permitted others to celebrate his seventieth birthday, even though after prolonged arguments and entreaties on the part of his friends and disciples. He knew well that many people would come to congratulate him, make speeches, read numerous messages, etc., etc., and that he would have to bear it all. He complained to his wife about it the evening before.

"I really don't know how I shall be able to stand it, Mother. And why did they start all this fuss anyway? I know, I know what you will say; it is not for me they are doing it. And yet... Oh well, there is nothing to be done about it now, I guess. It is too late. Only I am afraid it will make me ill... Okh."

But it did not make him ill. It came off very solemnly, but nevertheless nicely. Everyone at the Bureau was in a festive mood; in the chemical laboratory chocolate was served á la chemie, in beakers instead of cups, with glass rods in the place of spoons, while sheets of filter paper served for napkins. Complicated pieces



MENDELÉEF AND SOME OF HIS CO-WORKERS

of apparatus, all set for operation, were decorated with live flowers, so that it appeared that they were received in a chemical manner. Here came all who had already visited the savant at his home, where the old man had received delegation after delegation and listened to congratulatory speeches since one o'clock in the afternoon. Even the stiff Academy of Science had sent a delegate who in his address admitted the important contributions the father of the periodic system had made toward the advancement of science. Thus the Academy attempted to deny the charge of being self-satisfied in its sepulchral dignity. Mendeléeff made no fuss and did not get out of harness. He was really touched, convinced that his countrymen were really proud of him, and that everyone was glad of the opportunity to show the grand old man their affection.

Late that afternoon Miss Ozarovskaya entered to present the flowers the girls of the Bureau had sent him. Nor was it necessary to tell him that those tangible blossoms were the gift not only from the feminine employes but from every Russian woman for whom he had made it possible to follow a scientific career. It was well known that he had been the first to lecture in the earliest institutions of higher learning for women.

Dmitri Ivanovitch was evidently moved by the flowers.

"Akh, from the girls!" he said gently. "Flowers from the girls! They must be placed in water... Flowers from the girls." And he hastily took them into the dining room. He beckoned to Olga Erastovna to follow.

"Please do not go away," he said. "I have been waiting for you the whole day. I have to have drops poured into my eyes, and nobody here can do it."

The above might be construed to mean that pouring drops into Dmitri Ivanovitch's eyes was one of Miss Ozarovskaya's daily occupations. Not at all. It was the first time he had ever asked her. It was this lack of faith in those about him that tired and exhausted him so. His wife, who with her tact and good sense had helped to make this festive occasion so beautifully simple and intimate, smiled.

"Everybody can do it to perfection," she whispered. "Only he won't let them."

And Dmitri Ivanovitch continued, "My librarian usually does it for me, but she doesn't know how, always pours more outside than inside. Anyhow, she is not here today."

On the library table lay a stack of congratulatory telegrams which took him months to answer, as he absolutely refused to insert an announcement in the newspapers with the hackneyed acknowledgment, "Being unable to reply personally to all those who were kind enough, etc., etc."

"What an admission of impotence!" he grumbled when the suggestion was made to him. "Why admit it in print?"

And he replied to each and every message personally and fully.

When the last of guests had departed, he went into his study. The eye-dropper had already been filled, but Dmitri Ivanovitch somehow began to doubt Miss Ozarovskaya's efficiency as a squirter.

"Have you ever done this before?" he inquired.

"Oh, hundreds of times."

She was lying; it was the first time in her life she had ever attempted it.

"All right, then," he assented resignedly. With that he bent forward, stretched his neck so that his head bent downward and closed his eyes. Olga Erastovna looked at him. With his head in this position it was small wonder that most of the drops his librarian had tried to pour into his eyes had spilled over his cheeks. She decided on vigorous measures. With her free hand she suddenly grasped his forehead and bent it backward. Mendeléeff opened his eyes wide with surprise at her audacity, and squirt! The drops were in.

"Oho! Splendid!" he squawked with pleasure. "But was it not too much, eh?"

"Exactly one drop."

She lied again. Anyhow, it was no use trying to get the extra drops now.

"Excellent!" he said again with apparent satisfaction. "Only the professor himself can do it as well as you. His assistant—well, not quite. Splendid. Much obliged!"

Dmitri Ivanovitch struck and sometimes embarrassed strangers by his predilection for the use of strong terms. He called a spade a spade, in peasant fashion. Sometimes he was a little indirect, using a neat little swear word. He was especially fond of one expression

which cruelly, but potently, signified aimless plodding in the field of science. For instance, someone would begin to explain to him a proposed plan of research. Mendeléeff would listen attentively for a while, realize its insignificance, and then—Zip! He had said his piece.

Everyone at the Bureau was afraid of that expression, and it taught them not to deal with trifles, or to accept pedantry and triviality for accuracy and scientific attainment.

It is true that shortly after the arrival of Olga Erastovna at the Bureau everybody and everything seemed to look brighter and cleaner. In fact, they had not used any swear words for days. But Dmitri Ivanovitch soon got used to her and expressed himself in her presence as he saw fit. Some of the people present at these explosions would sometimes glance in her direction. He would take the hint and say, "What? Olga Erastovna? She is used to it. She realizes that it is impossible not to cuss on occasion."

One of the most inexplicable things about the great scientist was his superstition. He never permitted his subordinates to begin any important piece of work on certain days. For some reason he ascribed special significance to the number 7; it was a lucky number, he thought. But he religiously avoided the number 13. The following incident is a perfect illustration of his aversion.

Whenever Dmitri Ivanovitch was away from Russia and was about to return he would always notify the Bureau of the day of his arrival, when it was customary for the staff or at least the most important members of his scientific household, so to speak, to meet him at the station. Well, on one such occasion he wrote the Bureau that he was returning on such and such a day.

"Our chief must have got mixed up with his dates," observed one of the staff, "or he would never have left Paris on that date."

"Why?" he was asked.

"He has been reckoning his days there according to the Gregorian calendar so long, that he did not realize that he was leaving on the thirteenth according to the Julian calendar. He'll take a fit when the truth dawns on him."

To be sure, Mendeléef did not show up on the day or on the train he was expected, but came the next day. He was greatly excited and proceeded at once to explain the reason of his delay. It appeared that he had to change trains in Berlin. The porter had placed him in the waiting room and said that he would come for him when his train had arrived. However, as he sat there quietly he suddenly espied an approaching train marked "St. Petersburg—Paris," so he grabbed his luggage and made for the coach. It was not until six hours afterward that the conductor realized that Dmitri Ivanovitch was going back to Paris on a ticket good only in the opposite direction. The professor had to pay for the undesired journey and get out at the next station.

"And all because I started on the thirteenth," he assured everybody. "Got mixed up with the new style calendar, the devil take it!"

Another illustration.

Whenever he saw somebody looking well he would express his approval and follow it up by a few taps on the table with his finger as he repeated several times, "Touch wood, touch wood!"

How could this juxtaposition of science and superstition be explained? Let others try it. Perhaps it was his way of accounting for or indicating the limits of human knowledge. For he was very conscious of these limitations, he who knew so much and who had even foretold so accurately some of the discoveries yet to be made.

LECTURE DEMONSTRATION EXPERIMENTS*

R. D. BILLINGER

Lehigh University, Bethlehem, Pennsylvania

THERE are always several requirements for a successful lecture demonstration. Among these may be listed (1) the demonstration should explain a definite principle or process; (2) it should be brief in duration; too great a time should not be allowed to elapse before something happens; (3) the set-up should not be too complicated; (4) apparatus must be large enough to be seen and arranged for maximum visibility; (5) the experiment should be as fool-proof as possible. This requires selection of workable experiments, a good lecture assistant and careful checking.

Three experiments which have been found to meet the above requirements are submitted.

1. The Contact Process for Sulfuric Acid.—Figure 1 shows a diagrammatic sketch of the apparatus used to

* Presented before the Division of Chemical Education at the ninety-second meeting of the A. C. S., Pittsburgh, Pennsylvania, September 10, 1936.

illustrate the contact process for the preparation of sulfuric acid. Sulfur dioxide is prepared in flask (*A*) by dropping concentrated sulfuric acid on a concentrated (40 per cent.) solution of sodium bisulfite. A wash bottle (not shown in diagram) containing concentrated sulfuric acid will serve to indicate the rate of evolution of SO_2. The sulfur dioxide passes through a drying tower (*D*) and then is mixed with oxygen and passed over the boat (*E*) containing platinized asbestos. The oxygen coming from a gas cylinder is likewise bubbled through a wash bottle (*B*) of sulfuric acid and a drying tower (*C*) containing calcium chloride. The boat containing the catalyst is heated in the gas furnace (*F*) to about 400°C.

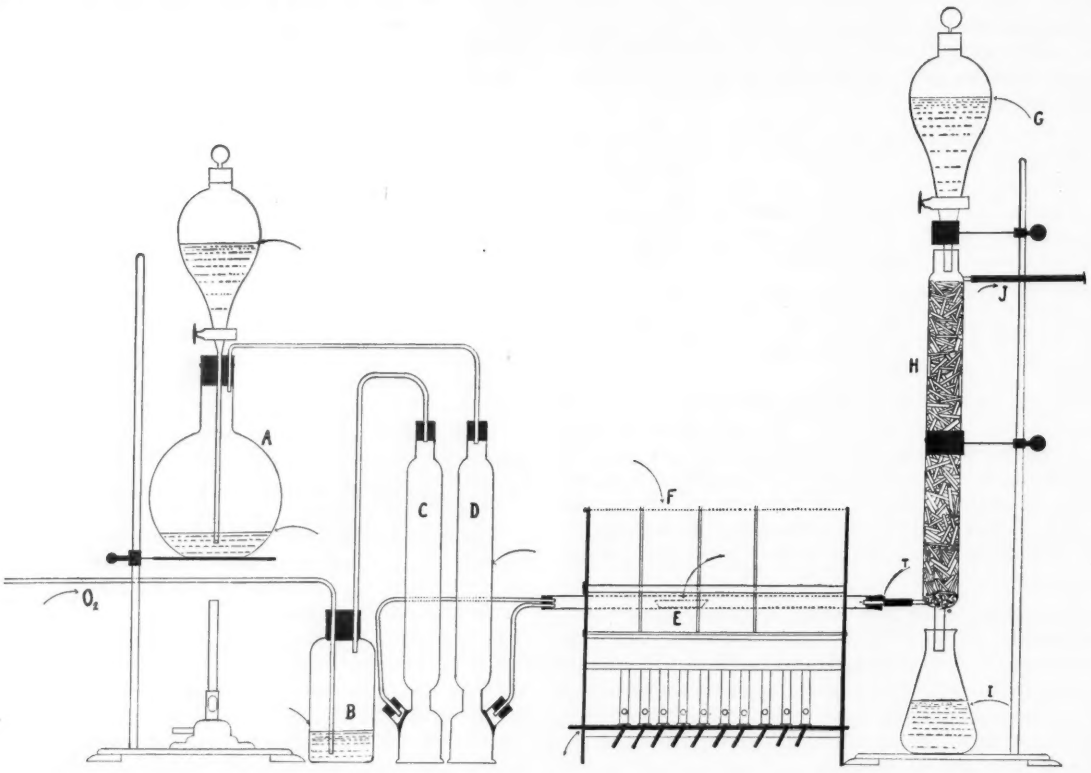


FIGURE 1

Under the above conditions almost complete transformation of sulfur dioxide to trioxide occurs. We usually show the class the heavy white fumes which emerge from the silica tube of the furnace. The gases are allowed to collect in a liter flask (not shown in diagram) connected in a parallel line by means of a T-tube at point *T*. By adjusting pinch clamps the direction of flow of the sulfur trioxide can be regulated. Next the white fumes are allowed to pass through the absorbing tower (*H*). This can be constructed easily by using the outer jacket of a condenser tube filled with short pieces of glass tubing and broken glass. A bit of glass wool at the bottom will serve to support the glass packing. The fumes may be drawn slowly through the tower by attaching (*J*) to suction. From the dropping funnel (*G*) concentrated sulfuric acid is dropped slowly to absorb the fumes of sulfur trioxide. The fuming sulfuric acid which is formed is collected in the Erlenmeyer flask (*I*). The experiment serves to illustrate the important steps in the contact process—(1) combination of sulfur dioxide and oxygen at suitable temperatures, (2) absorption of sulfur trioxide in 98 per cent. sulfuric acid.

Since so many important principles and applications are described in the lectures on this subject, it seems equally essential to accompany it with a good demonstration. While the above set-up is somewhat elaborate, it readily demonstrates the important steps in the process.

2. Preparation of Oxygen from Potassium Chlorate.—Caution. (The heating of potassium chlorate to prepare oxygen is a lecture demonstration which requires considerable care. In the first place the chlorate must be absolutely free from carbon or other impurities, and the manganese dioxide which is added as a catalyst also must be of high grade. If by any chance a bottle containing carbon instead of MnO_2 were picked from the

shelf by mistake, a disastrous explosion would result when the mixture was heated. It is well to test the reagents by heating a small quantity of chlorate and manganese dioxide together in a small test-tube prior to any large scale experiment.)

The following procedure devised by Dr. H. M. Ullmann of Lehigh University has proved successful as a lecture experiment.

The apparatus shown in the diagram (Figure 2) is conveniently arranged for the addition of the catalyst to the fused chlorate. A two-liter flask (three-necked)

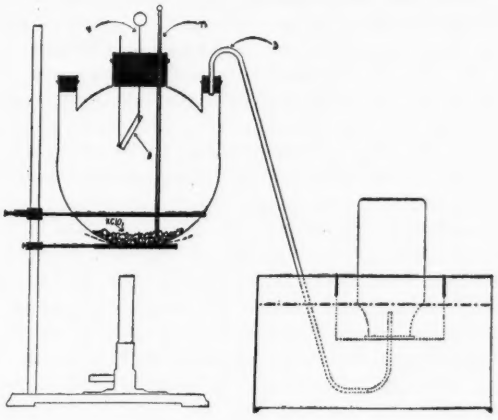


FIGURE 2

is used as the generating flask. About six ounces of dry potassium chlorate is carefully heated by means of a Bunsen flame. A wire gauze is used to assure more uniform heating. The bulb of a 500° Centigrade thermometer (*Th*) is immersed in the chlorate, but kept from touching the hot flask-bottom. *B* is a glass bucket 3 cm. long prepared from 14-mm. glass tubing. This bucket contains five grams of manganese dioxide. It is held in position by two copper wires as shown. Wire (*W*) is movable and serves as a release by means of which the bucket can be tilted. When the ring at the top of (*W*) is pulled upward the bucket swings mouth downward and spills its content of manganese dioxide.

The delivery tube (*D*) should be made sufficiently wide (12 mm. in diameter) to allow for rapid evolution of oxygen.

The flask is slowly heated to about 340°C. before the potassium chlorate appears to melt. At this stage it can be shown that very little evolution of oxygen is occurring. Now lower the flame slightly and add the catalyst in the method described. The immediate and rapid evolution of oxygen will be apparent and several jars of the gas can be collected in short time.

The design of the apparatus obviates the necessity of removing the central stopper during the heating. This prevents any back rush of water from the pneumatic trough to the hot flask. When the liberation of oxygen has ceased the third rubber stopper is quickly removed in order to establish atmospheric pressure in the flask.

The class should be told that complete decomposition of potassium chlorate requires temperatures above 600°; also that manganese dioxide itself will liberate

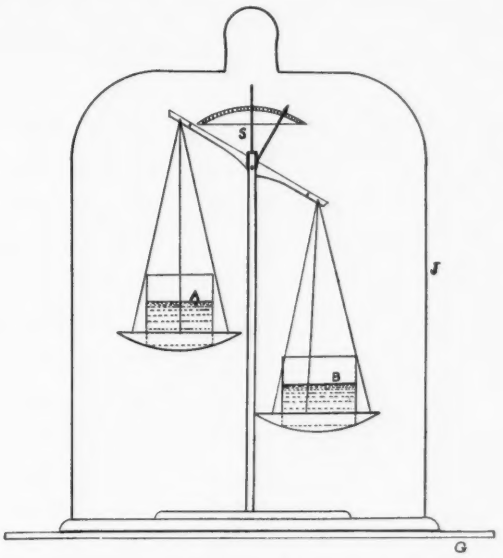


FIGURE 3

oxygen about 400°. By adding the catalyst, however, to potassium chlorate, oxygen can be evolved at temperatures as low as 200°.

3. Demonstration of Vapor Pressure Contrast.—The following experiment is designed to show the lower vapor pressure of a solution of a salt in water compared to the vapor pressure of the original solvent. Figure 3 shows a simple lecture demonstration for this purpose.

A small scale (*S*) is set up under a large bell jar (*J*). On one pan is placed a beaker (*A*) of distilled water, while on the other is placed a beaker (*B*) containing a sufficient quantity of a concentrated salt solution to exactly balance the scale. Sodium thiosulfate is a suitable solute for (*B*). The edges of the bell jar should be greased and set upon a glass plate (*G*).

In the course of the lecture hour there will be an appreciable change in the position of the scale arms. The side supporting the solution will be lowered, due to an increase in weight. The explanation should show the difference in vapor pressures of solvent and solution. After a time the air in the jar becomes saturated with water vapor and then water distils over from *A* to *B*.

To obtain as marked a difference as is shown in the diagram requires a period of several hours, and this can be shown again at the next lecture period.

Dr. T. H. Hazlehurst of Lehigh University suggested this variation of the experiment, which is described in several texts.

COLLATERAL READINGS *in* ORGANIC CHEMISTRY*

L. A. GOLDBLATT

Erie Center, University of Pittsburgh, Erie, Pennsylvania

AUTHORS of texts in general chemistry commonly recognize the desirability of references to corroborative and supplementary literature. This is evidenced by the frequency with which references to articles and books appear at the end of most chapters in texts on general chemistry. As a matter of fact, some even cite so many that a student could spend a whole semester reading only the references at the end of a single chapter, though no such student has yet been discovered. The value of such references is open to question, and, obviously, full use is not being made of them. In a number of cases blanket inquiries directed to whole classes in elementary organic chemistry, normally the second-year course, failed to elicit the name of a single chemical journal or journal devoted largely to chemistry, or even a single eminent chemist—that is, a live one. The latter situation has been remedied to some extent during the past few years, since two American chemists achieved the Nobel Laureate and the front page. However, the average undergraduate is still quite unaware of any chemical journals—even THIS JOURNAL.

Perhaps it is the frank recognition of this situation that prompts the reverse attitude among authors of texts in organic chemistry. It is the exceptional text in elementary organic chemistry that makes any pretence at citing references to source material. Yet it is precisely here that a more intensive effort should be made to acquaint the student with the existence of a chemical literature and to cultivate the art of broad professional reading. The chemist leans heavily upon the various kinds of available chemical publications; the student, would-be chemist or not, should be acquainted with the existence of this literature.

Organic chemistry presents an excellent meeting ground for such an introduction. Organic chemistry is a living science, even though the term itself is no longer restricted exclusively to the living. Examination of the journals published or sponsored by the American Chemical Society will reveal the existence of a truly surprising number of articles which are intelligible to the student who has already studied college chemistry for one or two years. Such articles may be incorporated in the formal course very profitably. The modern textbook of elementary organic chemistry furnishes an extremely concentrated diet of factual data as difficult for the student to assimilate as so much graphite and cellulose and about as nourishing. The gaunt skeleton of the facts is far more pleasing when it is filled in and rounded out with details that basically, perhaps, are less essential, but are nevertheless important to the broader development of the student. These details no text can give, for, after all, the text is built up by the extreme condensation or rectification of thousands of articles in the literature. Properly selected articles not only serve to introduce the student to the chemical literature, but they broaden his perspective of the field of organic chemistry. They supply breadth to the depth of the text. In addition, they offer a welcome diversion from that apparently endless series of formulas, reactions, syntheses, degradations, rearrangements, etc., of "organic" and provide an excellent source of inspirational material.

During the past year the assignment of such articles as required collateral reading was undertaken in a small class in organic chemistry. While these innovations were received with varying degrees of enthusiasm, the student response was, on the whole, quite satisfactory. In answer to an inquiry at the end of the year none would admit that such assignments were wholly without value, and a few went so far as to say that this constituted one of the more outstanding features of the course. On the average, about one article of rather less than an hour's reading time was assigned each week. A report was required on each article assigned, but the mechanics of reporting were simplified as much as possible. Each report was required to include four items. These were (1) the title, author, and reference in the form in which it would appear as a reprint from the *Journal of the American Chemical Society*, (2) the reading time, (3) a letter grade, A, B, C or D, to indicate the verdict, or judgment, as to the quality, or value, of the article and (4) comment. The comments, which were left entirely to the student's discretion were extremely varied and frequently wholesomely frank. Some undertook abstracts, more or less brief; some extracted phrases or sentences which seemed to them particularly interesting or informative (and these, too, were frequently revealing); others chose to offer a critical review. Of all the reports submitted, only a very few carried no comment.

The value of such collateral readings was amply demonstrated. However, assignments have to be made quite carefully and only after full consideration of the present status of the student's knowledge. Articles

* Based upon a paper presented before the Division of Chemical Education at the ninety-second meeting of the A. C. S., Pittsburgh, Pa., September 11, 1936.

must contain an absolute minimum of material which is not readily intelligible to the student and should contain no material for which the text has not already supplied a basis. Thus, if a student is still grappling with the aliphatics, the appearance of even a single benzene ring in an otherwise entirely intelligible article will cause him to flounder helplessly. Such an article will be condemned by the demoralized student as being entirely beyond his depth—or over his head. Even now the recollection of some of the comments received on one particular theoretical article, which on first consideration appeared to offer no excessive or unreasonable difficulties is discomforting. Some articles assigned quite unhesitatingly were as unhesitatingly graded D. This was the lowest grade given; apparently the simple fact of publication warranted a passing grade. Other articles assigned with some misgiving were received with acclaim as the best article to date. Such judgments, of course, are not entirely trustworthy. For example, in one extreme instance the same article was cited by one student as the worst yet assigned and by another as the best he had yet read—without, however, specification as to precisely how many he had read. One paper dealing with fluorides as refrigerants, assigned with some trepidation, brought forth a series of enthusiastic comments from a group of premedical students elated with the details of some animal experiments designed to test the toxicity of the refrigerants. This, apparently, was their first contact in chemistry with anything which seemed to them of direct bearing on their medical work.

It is necessary, also, to strike a balance between articles which are essentially theoretical, industrial, and historical in nature. The average liberal arts student will resent the introduction of an excessive amount of material which is essentially industrial or engineering chemistry in nature. He will similarly resent an excess of the purely historical type of material, as it seems to him that this simply adds to the burden of an already overladen course.

The chief difficulty and probably the prime reason for the relatively few extra-textual assignments lies in the difficulty of securing adequate numbers of the requisite journals. Smaller institutions simply do not subscribe to such journals, and larger institutions do not have a sufficient number of copies for their correspondingly larger numbers of students. Last year the problem was solved temporarily by using borrowed journals. A successful assignment was readily recognized when the journal was returned, for the relation between article interest and journal depreciation was simple and direct. One issue which contained a symposium on fermentation simply could not be used again. On the whole, the students suffered less than the journals.

For this year a volume of those articles which seemed most desirable from the point of view of student reaction and educational value was reproduced in lithoprinted form. Lithoprinting the complete articles, essentially a photographic process, permits the exact, facsimile reproduction of the material as it appears in the journals, and at a considerably lower cost than would be required for printing. The editors of the various journals have been extremely generous in giving permission to reproduce articles. In this way a volume of about thirty articles was reproduced to be sold to stu-

TABLE 1

TABLE OF CONTENTS TAKEN FROM "COLLATERAL READINGS IN ORGANIC CHEMISTRY"

I. The Romance of Carbon. Arthur D. Little, *Ind. Eng. Chem.*, **18**, 444–51 (1926) 1

II. A. The Number of Isomeric Hydrocarbons of the Methane Series. Henry R. Henze and Charles M. Blair, *J. Am. Chem. Soc.*, **53**, 3077–85 (1931) 9

B. The Number of Structural Isomers of Certain Homologs of Methane and Methanol. Douglass Perry, *J. Am. Chem. Soc.*, **54**, 2918–21 (1932) 11

III. A. The Petroleum Industry of 1935. J. Bennett Hill, *Ind. Eng. Chem.*, **27**, 519–24 (1935) 12

B. Progress in Petroleum Hydrogenation. *News Edition, Ind. Eng. Chem.*, **10**, 205–7 (1932) 18

IV. A. Acetylene Polymers and Their Derivatives. I. The Controlled Polymerization of Acetylene. J. A. Nieuwland, W. S. Calcott, F. B. Downing, and A. S. Carter, *J. Am. Chem. Soc.*, **53**, 4197–202 (1931) 19

B. Acetylene Polymers and Their Derivatives. II. A New Synthetic Rubber: Chloroprene and Its Polymers. Wallace H. Carothers, Ira Williams, Arnold M. Collins, and James E. Kirby, *J. Am. Chem. Soc.*, **53**, 4203–25 (1931) 22

C. Economics of Synthetic Rubber. E. R. Bridgwater, *Ind. Eng. Chem.*, **27**, 394–8 (1936) 25

V. Organic Fluorides as Refrigerants. Thomas Midgley, Jr. and Albert L. Henne, *Ind. Eng. Chem.*, **22**, 542–5 (1930). 30

VI. A. Chemicals Derived from the Pentanes. *News Edition, Ind. Eng. Chem.*, **11**, 334 (1933) 33

B. Amyl Alcohols from the Pentanes. Eugene E. Ayres, *Ind. Eng. Chem.*, **21**, 899–904 (1929) 34

VII. Butanol Fermentation Process. C. L. Gabriel, *Ind. Eng. Chem.*, **20**, 1063–7 (1928) 39

VIII. Early History of Acetaldehyde and Formaldehyde. Frederick Walker, J. CHEM. EDUC., **10**, 546–51 (1933) 44

IX. Organic Deuterium Compounds. Acetic, Malonic, and Succinic Acids. J. O. Halford and Leigh C. Anderson, *J. Am. Chem. Soc.*, **58**, 736–40 (1936) 50

X. Metallic Soaps—Their Uses, Preparation, and Properties. Willett F. Whitmore and Michael Lauro, *Ind. Eng. Chem.*, **22**, 646–9 (1930) 55

XI. A. The Catalytic Hydrogenation of Organic Compounds Over Copper Chromite. Homer Adkins and Ralph Connor, *J. Am. Chem. Soc.*, **53**, 1091–5 (1931) 58

B. The Catalytic Hydrogenation of Esters to Alcohols. Homer Adkins and Karl Folkers, *J. Am. Chem. Soc.*, **53**, 1095–7 (1931) 60

C. The Preparation of Copper-Chromium Oxide Catalysts for Hydrogenation. Ralph Connor, Karl Folkers, and Homer Adkins, *J. Am. Chem. Soc.*, **53**, 2012 (1931). 61

D. Hazards in Catalytic Hydrogenation at Elevated Temperatures and Pressures. Homer Adkins, *J. Am. Chem. Soc.*, **53**, 2808–9 (1931) 61

E. Sulfonated Higher Alcohols. D. H. Killeffer, *Ind. Eng. Chem.*, **25**, 138–40 (1933) 62

XII. Contemporary Reception of Wöhler's Discovery of the Synthesis of Urea. W. H. Warren, J. CHEM. EDUC., **5**, 1539–53 (1928) 64

XIII. A. 5,5-Substituted Barbituric Acids. E. H. Volwiler and D. L. Tabern, *J. Am. Chem. Soc.*, **52**, 1676–79 (1930). 71

B. Physico-Chemical Properties and Hypnotic Action of Substituted Barbituric Acids. D. L. Tabern and E. F. Shelberg, *J. Am. Chem. Soc.*, **55**, 328–32 (1933) 73

XIV. Cellulose in Industry. Hervey J. Skinner, *Ind. Eng. Chem.*, **24**, 694–704 (1932) 75

XV. The Evolution of Nutrition. J. G. Archibald, J. CHEM. EDUC., **11**, 601–8 (1934) 86

XVI. The Ozonides of Ortho-Xylene and the Structure of the Benzene Ring. A. A. Levine and A. G. Cole, *J. Am. Chem. Soc.*, **54**, 338–41 (1932) 94

XVII. Modern Developments in Synthetic Resins. Carleton Ellis, *Ind. Eng. Chem.*, **26**, 37–40 (1934) 96

XVIII. Development of Synthetic Phenol from Benzene Halides. William J. Hale and Edgar C. Britton, *Ind. Eng. Chem.*, **20**, 114–24 (1928) 100

XIX. The Structure of Naphthalene. Louis F. Fieser and Warren C. Lothrop, *J. Am. Chem. Soc.*, **57**, 1459–64 (1935) 111

XX. Relation of the Dyestuff Industry to Other Industries. Ivan Gubelman, *Ind. Eng. Chem.*, **27**, 618–26 (1935) 115

XXI. Prize Winners in Chemistry—Nobel Prize. James A. Funkhouser, *News Edition, Ind. Eng. Chem.*, **14**, 182 (1936). 124

Appendix 125

dents for a dollar.* That does not seem an excessive sum to add to the student's investment in organic chemistry.

It is recognized that such a collection has the disadvantage of not giving the students direct access to the journals proper. However, this does take the first step, and it is planned to supplement this collection toward the end of the year, after ample opportunity has been provided for the student to become oriented, with additional individually selected articles. On the other hand, this method of presentation has several advantages from a pedagogical point of view. An opportunity is provided to include the small amount of introductory or explanatory material which will frequently clarify any minor, but, nevertheless, annoying difficulties a student may encounter. Another advantage is that several related articles appearing at different times, possibly in different journals, may be grouped together, giving a more unified picture to the student who has not yet learned to correlate readily the content of different articles. In such cases, instead of taking the entire articles, only the relevant portions of the various articles need be reproduced. A wider range of selection is permitted, since the more difficult, or less pertinent, portions of an article may be omitted. A very definite advantage is that the student has the volume at home at his desk where it is available at all times for leisure reading, and he will not have to go the library for this material. We all know, from our own experience, that we are much more likely to read our chemical journals regularly when they arrive at our desk than when we depend upon a library copy. On the whole, provided it is sufficiently stressed that these are simply samples of what is to be found in the literature, and that the student is subsequently encouraged to do some sampling on his own account, the advantages of this method of presentation more than counterbalance the disadvantages.

The order of presentation of topics is that followed generally by texts in elementary organic chemistry. However, since the individual topics are treated as units and are not cumulative they may be assigned in any desired order. An appendix is included to furnish introductory or explanatory material and to cite one or two additional references to other suitable articles on each of the topics discussed. The list of articles as it appears in the Table of Contents is given in Table 1, and the space devoted to each topic may be inferred from the page numbers.

* GOLDBLATT, L. A., "Collateral readings in organic chemistry," Edwards Brothers, Inc., Ann Arbor, Michigan, 1936. v + 127 pp., 21.5 × 27.5 cm. $1.00.

A MELTING-POINT BATH

HAROLD P. BROWN

University of Kansas City, Kansas City, Missouri

THE hazards of sulfuric acid baths and the unpleasantness and inadequacies of oil baths for the determination of melting points and boiling points are well known. It is surprising that more satisfactory materials have not supplanted these substances which are commonly employed in laboratory practice.

For the needs of the chemist, and particularly of the student, dibutyl phthalate offers many advantages. The high boiling point of the commercially available product* of 340°C. at 760 mm. facilitates the duplication of virtually all melting points and boiling points above room temperature recorded in the literature for organic compounds. The material has the decided value of being liquid at room temperatures. Although the flash point of 180°C. limits the utility of dibutyl phthalate as a general purpose high-temperature bath, melting points as high as 300°C. can safely and readily be taken by using a Thiele tube or similar device exposing a small area of liquid surface in a relatively tall container. The rapidity of acquisition and loss of heat, the fluidity, the absence of corrosive action, the absence of highly irritating fumes, inexpensiveness, and clarity are other commending features of this material.

Although dibutyl phthalate decomposes and darkens somewhat when kept at elevated temperatures for long periods of time, it does not discolor seriously enough to render the determination of the desired points impractical. Clarification can be effected by distillation under reduced pressure, but it is usually more expedient to simply recharge the bath with fresh fluid. Students have experienced little difficulty in using dibutyl phthalate baths throughout the school year without recharging. Care must be exercised that rubber does not come in contact with hot dibutyl phthalate, as it will melt and discolor the bath. Melting-point tubes are readily held in place by the usual method of capillary attraction.

The replacement of sulfuric acid by dibutyl phthalate in melting-point baths removes one of the major sources of acid burns in the organic laboratory and, at the same time, furnishes a bath suitable for the determination of the highest melting points or boiling points commonly encountered which is liquid at room temperatures.

* Data given are for the product manufactured by Carbide and Carbon Chemicals Corporation.

The CORRELATION *of* GRADES RECEIVED *by* STUDENTS *in* SUCCESSIVE COLLEGE CHEMISTRY COURSES*

CARL OTTO

University of Maine, Orono, Maine

THE correlation between the grades obtained by students in aptitude tests with their later performance in general chemistry has been studied by Smith and Trimble (*1*), Bird (*2*), and Stout (*3*). The consensus of opinion of these men is that the correlation is fair as a whole, Stout showing that it becomes progressively worse with successive quarters, while Smith and Trimble point out that it is more consistent for the best and poorest students than for the mediocre ones. Herrman (*4*) and Glasoe (*5*) concur in the opinion that the taking of high-school chemistry is an aid to the later performance in college chemistry. West (*6*) states that other factors, such as intelligence, are more important than the number of units of high-school science taken by the students. Scofield (*7*) correlates the grades received in high-school mathematics, chemistry, and physics, separately and grouped, and those in placement tests with the grades in the first and second semester of general chemistry. Her conclusions are that a combination of good high-school grades is better than the grades in any one subject, or in the placement tests, in differentiating the good students from the rank and file, but that placement tests indicate more clearly the poor students.

So far as the author is aware, no study has been made of the correlation of grades obtained in successive college courses. Since he teaches qualitative analysis in the first semester and elementary quantitative analysis in the second semester to second-year students, he is mainly concerned with the students' performance in these courses as compared to preceding and succeeding courses. This study was prompted somewhat by the queries of students as to their probable success in the courses they were beginning and in the courses they would take next. It was thought that the best answers to these questions could be found in the records of the past. The available grades in certain chemistry courses of all the students that the author has had in his classes at the University of Maine were obtained. The grades of a few transfer students who had begun their chemistry in other institutions were not on record and hence are not in the compilation. The preparation of the students represented in this study was, therefore, more nearly equal at the beginning of a course than it would be for general chemistry students entering from various high schools, some with and some without chemistry.

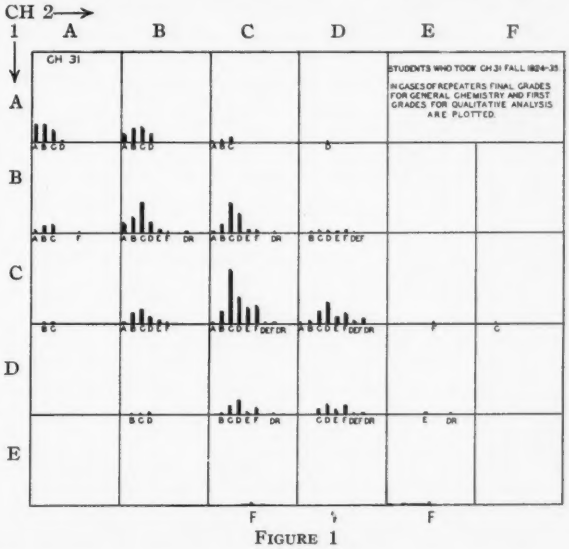


FIGURE 1

The correlation between general chemistry and qualitative analysis was begun in 1924, that between qualitative analysis and quantitative analysis and between quantitative analysis and physical chemistry in 1930. The summation of records is made graphically (Figure 1) so that it can be kept up to date at all times. On this chart each small square represents one student. The grades for the two semesters of general chemistry are shown separately so that the progressive rise and fall of grades can be noted. Each large vertical division represents the various grades in the first semester of general chemistry (Ch 1), each large horizontal

* Presented before the Division of Chemical Education at the ninety-second meeting of the A. C. S., Pittsburgh, Pennsylvania, September 10, 1936.

division, the grades in the second semester of general chemistry (Ch 2). In the square formed by the projection of a vertical and a horizontal division are plotted the results in qualitative analysis (Ch 31) of students

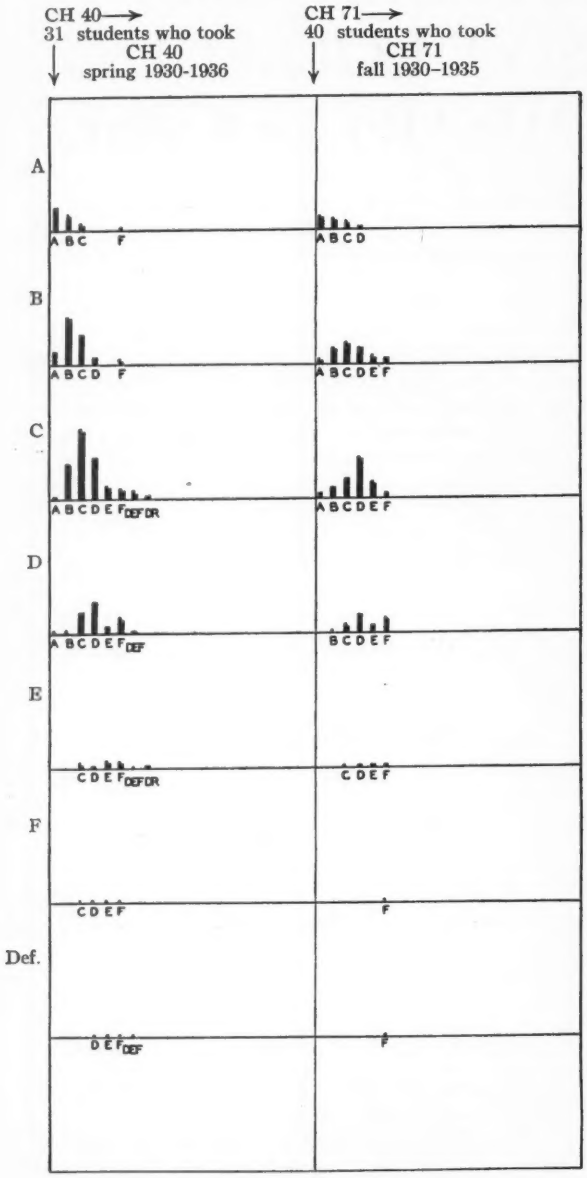


FIGURE 2

receiving that combination of grades in general chemistry. Thus, the square in the second row and third column presents the qualitative analysis grades of those students who got B in the first semester and C in the second semester of general chemistry. The columns in the squares are the various qualitative grades and the height of each column, formed by blackening in one small square for each student belonging there, indicates the number receiving that grade up to the present time. To avoid excessively high columns, the latter are made two squares wide and columns representing an odd number of students have irregular tops. In the cases of students who repeated courses the last grade obtained in an elementary course previous to taking an advanced course was plotted against the first grade obtained in the advanced course. Subsequent grades for those students were not used. The total number of students represented on the chart as shown is 654.

It can be seen that in each of the squares the grades in qualitative analysis follow approximately a probability curve with the maxima falling lower with lower grades in general chemistry, but that even with low grades in general chemistry it is still possible for an occasional student to get a high grade in qualitative analysis. Thus, two students who got C both semesters in general chemistry received A in qualitative analysis, and contrariwise, two students who got A both semesters of general chemistry received D in qualitative analysis. As an example to illustrate the interpretation of the chart, suppose we consider the record of those who got A the first semester and B the second semester in general chemistry. We find that 9 got A, 16 got B, 17 got C, and 10 got D. There were no E's, F's, "Dropped" (Dr), or "Deficient" (Def). From this it can be predicted that a student who has obtained these grades in general chemistry has a 17 per cent. chance to get an A, a 31 per cent. chance to get a B, a 33 per cent. chance to get a C, and a 19 per cent. chance to get a D. It can be seen from the chart that seven students who had not at that time passed one or both semesters of general chemistry were permitted to take qualitative analysis and that only one of these was successful. These rather peculiar registrations were made with the hope that the students would be able to complete their requirements for graduation in the usual four years. They were, of course, repeating general chemistry at the same time they were taking qualitative analysis.

Correlation coefficients of mean square contingencies and regression equations have been calculated considering the semesters of general chemistry separately. The correlation coefficient between the first semester of general chemistry and qualitative analysis is 0.53 ± 0.02 and between the second semester of general chemistry and qualitative analysis is 0.60 ± 0.02. These show more definitely but no more clearly than the charts themselves the relation between the students' grades in the three courses. The probable grade that an individual student will receive can be estimated by the following equations which have been derived from the data:

$$X = 0.9Y - 0.7 \pm 1.1$$
$$X = 1.2Z - 1.2 \pm 1.0$$

where X represents the grade in Ch 31, Y the grade in Ch 1, and Z the grade in Ch 2, the letter grades A, B, C,

etc., being given the numerical values 4, 3, 2, etc., respectively. To illustrate the use of these equations suppose a student has received an A grade in Ch 1 and a B grade in Ch 2. His probable grade in Ch 31 is 2.9 ± 1.1 or 2.4 ± 1.0, depending on which equation is used. In other words he has more chances of getting a C than any other grade and a B rather than a D. This bears out the qualitative observations made above.

The correlations of qualitative analysis with quantitative analysis for 329 students and of quantitative analysis with physical chemistry for 187 students have been made in a similar manner. The number of students is smaller, first, because the compilations were started later and, second, because there is a decrease in number of students with advancing classes. The data are portrayed in Figure 2. These are simpler than the first because the grades in one instead of two previous semesters are plotted against the advanced course grade. Therefore, only one column of large squares is needed for charting each pair of courses. The interpretations of these is similar to the preceding. The correlation coefficient between qualitative analysis and quantitative analysis is 0.80 ± 0.014 and the regression equation is

$$W = 1.2\ X - 0.8 \pm 0.6$$

where W represents the grade in quantitative analysis. The correlation coefficient between quantitative analysis and physical chemistry is 0.72 + 0.024 and the regression equation is

$$U = 0.9\ W - 0.7 \pm 0.7$$

where U represents the grade in physical chemistry.

The correlation coefficients are worth examining with regard to the instructors of the courses. The highest coefficient (0.80) was obtained between the author's own classes of qualitative and quantitative analysis. In these he has practically complete, direct supervision. The next highest (0.76) was between the two semesters of general chemistry, considering not the whole class, but only those who continued chemistry. The students in this course have the same lecturer for the two semesters, but frequently different recitation and laboratory instructors. Quantitative and physical with a coefficient of 0.72 are taught by different instructors who are, nevertheless, somewhat similarly inclined. General chemistry and qualitative analysis, showing the correlations 0.53 and 0.60, are likewise given by different instructors, and these low correlations may be due to that influence. The fact that the second semester of general chemistry is largely qualitative analysis does not seem to help materially its correlation with the sophomore course of qualitative analysis.

Since it was desired to ascertain the prognostic value of certain course grades, a study of the correlations of the accumulative average at graduation with qualitative analysis grades and with physical chemistry was made. The records of one hundred thirty students (all who graduated in the years 1932 to 1935, inclusive) showed the remarkably high correlation coefficient of 0.81 ± 0.05 between qualitative analysis and the accumulative average and those of one-hundred twenty-eight students a coefficient of 0.45 ± 0.05 between physical chemistry and the accumulative average. The former value indicates that the grades in a course early in the curriculum can aid materially in predicting a student's success in college. Perfect correlations could not be expected for many factors, such as sickness, extra-curricular activities, the newness of college life to freshmen, emotional upsets, the different manipulative skill required in different courses, etc., undoubtedly contribute to rendering them imperfect. In general, it can be concluded that a student's grades tend to slide slightly lower with successive courses.

In closing, I wish to acknowledge the valuable assistance of Mr. George Cunningham in the calculation of the statistical data.

LITERATURE CITED

(1) SMITH, O. M. AND TRIMBLE, H. M., "Prediction of future performance of students from their past record," J. CHEM. EDUC., **6**, 93–7 (1929).
(2) BIRD, KENNETH L., "The use of an aptitude test as a basis for sectioning freshman college students," *ibid.*, **7**, 1118–21 (1930).
(3) STOUT, LAWRENCE E., "The selective value of Powers general chemistry test scale A," *ibid.*, **3**, 1138–43 (1926).
(4) HERRMAN, GEORGE A., "An analysis of freshman college grades with reference to previous study of chemistry," *ibid.*, **8**, 1376–85 (1931).
(5) GLASOE, PAUL M., "Residue of high-school knowledge utilizable in college chemistry," *ibid.*, **10**, 571–4 (1933).
(6) WEST, G. A., "Influence of high-school science on grades in college chemistry," *Sch. Sci. & Math.*, **32**, 911–3 (1932) (through J. CHEM. EDUC., **10**, 255 (1933)).
(7) SCOFIELD, MAUDE B., "Further studies on sectioning in general chemistry," *ibid.*, **7**, 117–26 (1930).

FIRST ANNUAL CHEMISTRY ALUMNI DAY AT RHODE ISLAND STATE COLLEGE

At the suggestion of Professor J. W. Ince, head of the department of the college, the first annual chemistry alumni day was held on May 29th. A number of alumni of the institution who are prominent in the field of chemistry returned for the activities, as well as to renew old friendships. Among them were Dr. Frederick J. Keyes, head of the department of chemistry of Massachusetts Institute of Technology, Dr. David Worrall of Tufts College, and others. In the afternoon a meeting of the alumni and staff was held in Ranger Hall, and a chemistry alumni association was formed. Professor J. W. Ince was named chairman, and Dr. W. G. Parks was elected secretary. Subsequently a meeting of the recently appointed Visiting Committee was held. This Visiting Committee, consisting of the following chemistry alumni, Dr. F. J. Keyes, Dr. David Worrall, Mr. Arthur Meyer, and Mr. Carl Bigelow were recently named by the president of the college to work with him and the chemistry staff for a more effective development of the chemistry department.

A SEMI-QUANTITATIVE VISUAL METHOD *for* COMPARING ELECTROLYTIC CONDUCTIVITIES *in* LECTURE DEMONSTRATIONS*

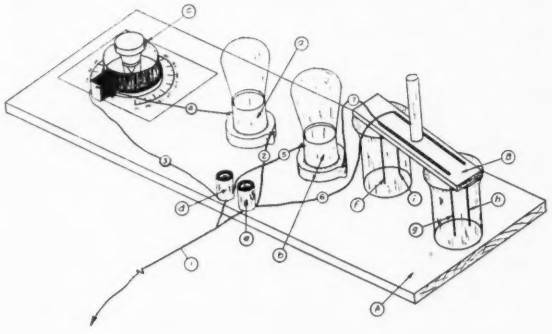
F. E. BROWN AND W. G. BICKFORD

Iowa State College, Ames, Iowa

ALMOST every laboratory manual for general chemistry describes an apparatus for comparing electrolytic conductivities. The apparatus usually consists of a dipping electrode in series with an incandescent light bulb and a source of electric current. Our modification of this simple apparatus consists (1) in adding a second circuit in parallel with the single circuit commonly employed, and (2) in using multiple electrodes, electrodes so arranged that the sum of the conductivities of two solutions may be measured, as well as the conductivity of any one solution.

The added circuit consists of a variable resistance and an incandescent light bulb, the reference lamp. The reference lamp should be as nearly like the test lamp (the incandescent light bulb used in series with the solutions) as possible. With a 110-volt circuit, 220-volt lamps or ordinary carbon-filament bulbs are quite satisfactory. The maximum resistance of the rheostat should be large enough almost or entirely to prevent the glowing of the reference lamp when the current is applied. The maximum resistance should not be less than 200 ohms, and 500 ohms is desirable. The resistance should be calibrated so that the resistance in series with the reference lamp may be determined within about 10 ohms. Resistances may be made by winding any wire having a fairly high resistance and melting point on a non-conducting frame. The wire may be obtained from old electric heaters.

The multiple electrodes may consist of two pieces of iron or nichrome wire bent into U-shapes and mounted rigidly at a convenient distance apart on a block of some non-conductor, of metal flags mounted rigidly on insulated wires, or of graphite rods suitably connected. The different pairs of electrodes should be similar, and if they consist of wires or rods, provision must be made for equal depths of immersion in the electrolytes when conductivities are to be compared. The presence of the second parallel circuit containing



the reference lamp and the calibrated variable resistance enables the demonstrator:

(1) to keep before his class a measure of the conductivity of any one solution while that solution is modified in any way or another solution is substituted for it;

(2) to recall the brightness of the test lamp under any previous condition under which it was matched by the reference lamp and the resistance in series with the reference lamp was recorded;

(3) to determine approximately the actual resistance between the electrodes as they stand in any particular electrolyte (when the two similar lamps are equally bright the resistances in the two circuits are approximately equal);

(4) to determine the relative specific conductivities or the relative equivalent conductivities or relative molar conductivities of any two solutions as accurately as the lamps can be matched; and

(5) to determine the absolute specific, absolute equivalent, or absolute molar conductivity of any of the solutions as accurately as the comparisons are made, if the conductivity of one of the solutions is known.

* Presented before the Division of Chemical Education at the Thirteenth Midwest Regional Meeting of the A. C. S., held at Louisville, Kentucky, October 31–November 2, 1935.

The apparatus in use in our lecture room consists of two pieces of board and the common electrical devices attached to them. The larger board, *A* (Figure 1), is 60 × 20 × 1.3 cm. (8 × 24 × 0.5 in.) To one of its faces are attached: two electric light sockets, *a*, in which is mounted the reference lamp, and *b*, in which is mounted the test lamp; a 400-ohm. variable resistance, *c;* and two binding posts, *d*, and *e*, which are connected by about six feet of drop cord, *1*, to the source of electrical current, to the reference lamp on one side by insulated wire, *2*, and on the other side through the variable resistance by insulated wires, *3* and *4*, and to the test lamp on one side by insulated wire, *5*, and on the other side through the electrodes mounted on the other board, *B*, by means of insulated wires *6* and *7*. The second board, *B*, is about 18 × 4 × 0.6 cm. (7 × 1.75 × 0.25 in.). On it are mounted four electrodes *f*, *g*, *h*, and *i*. The cathodes, *f* and *g*, were made by bending a piece of No. 8 B&S gage nichrome wire 30 cm. in length to form three sides of a square each 10 cm. long. The anodes, *h* and *i*, were made in exactly the same way. To one angle of the cathode was soldered one end of insulated wire, *7*, and to an angle of the anode one end of insulated wire, *6*. The middle third of each bent wire was covered by a piece of close-fitting rubber tubing. In board *B*, 4 cm. from each end and 0.75 cm. from each side were bored snugly fitting holes to receive the electrodes. Any movement of the electrodes is further hindered by slipping a one-hole No. 00 rubber stopper on each electrode and pressing it firmly against the board, *B*. The solutions to be used in the demonstrations are placed in ordinary 150-cc. lipped Pyrex beakers.

When the conductivity of a single prepared solution is to be tested, only one anode and one cathode are used. If a solution is to be diluted, the solution is placed in one beaker and the water to be used for dilution in a second beaker. One pair of electrodes is dipped into each beaker, and the sum of the conductivities of the two separate liquids is recorded by the reference lamp. Then the two are mixed, and the conductivity of the mixture is compared to the sum by comparing the brightness of the test lamp with that of the reference lamp.

Using this apparatus and carbon lamps, differences in conductivity can be recognized by large classes: (*a*) when 50 cc. of molar acetic acid is diluted to 100 cc. of 0.5 molar, (*b*) when 50 cc. of 0.5 molar ammonium hydroxide is diluted to 100 cc. of 0.25 molar, (*c*) when 0.02 molar solutions of sodium chloride and potassium chloride are compared (because of greater hydration of the sodium ion, in spite of its smaller mass, the sodium ion is a slower carrier of electricity than the potassium ion), and (*d*) when the temperature of a 0.02-molar solution potassium chloride is raised 20° within the range between 0° and 80°.

The multiple electrode enables the demonstrator to show: (1) the lack of conductivity simultaneously of the dry salt and pure water before they are mixed, (2) the sum of the conductivities of the water and a solution to be diluted as well as the conductivity of the original solution and the diluted solution, and (3) the sums of the conductivities of separate solutions as well as the conductivities of the mixtures of these solutions.

Some specific cases are interesting. (1) When multiple electrodes are dipped simultaneously into 50 cc. of 0.25-molar solutions of each of ammonium hydroxide and acetic acid in separate beakers, the test lamp glows feebly. When the solutions are mixed and the electrodes are again inserted, the lamp becomes brilliant. (2) If 0.02-molar solutions of sodium hydroxide and hydrochloric acid are used, the lamp is about as bright as for the separate solutions of ammonium hydroxide and acetic acid but almost ceases to glow when the solutions are mixed. (3) The sum of the separate conductivities of 0.01 molar solutions of ammonium acetate and hydrochloric acid is greater than their combined conductivity. In the case of ammonium hydroxide and acetic acid, two weak electrolytes are replaced by one strong electrolyte and water. The strong electrolyte, ammonium acetate, furnishes so many more ions than the sum of the ions furnished by the two weak ones, acetic acid and ammonium hydroxide, that much greater conductivity results even though the best conducting of all ions, the hydrogen and the hydroxyl ions, are those lost. In the case of sodium hydroxide and hydrochloric acid, two very strong electrolytes are replaced by one strong electrolyte and water. There is no increase in the number of sodium ions or chloride ions, and almost all of the hydrogen and hydroxyl ions unite to form water. The case of ammonium acetate and hydrochloric acid shows how the presence of ions other than hydroxyl ions can appreciably decrease the concentration of the hydrogen ions. In this case two strong electrolytes are replaced by a strong electrolyte and a weak electrolyte, and the weak electrolyte, acetic acid, forms many molecules and in that way removes many hydrogen ions and acetate ions from solutions.

The dimensions of the apparatus mentioned in this paper are merely those we happened to use. The concentrations and volumes were convenient for our apparatus. Any other dimensions within rather wide limits and then necessarily modified volumes, or concentrations, of solutions would do equally well. An ammeter visible to the whole class could be substituted for the two lamps. For small classes the lamps could be compared more exactly by a grease-spot photometer. However, the results will always be approximate and are designed for demonstration to large classes, not for exact work.

REPORT *of the* COMMITTEE *on* MINIMUM EQUIPMENT*

DIVISION OF CHEMICAL EDUCATION, AMERICAN CHEMICAL SOCIETY

THE Committee on Minimum Equipment for High-School Chemistry has completed its task and hereby submits the following report of its findings to the Division of Chemical Education of the American Chemical Society. The report contains seven lists designed to aid all chemistry teachers, but particularly those with little experience in small high schools with classes of eight to twelve pupils. The lists are as follows.

1. Experiments for which equipment has been listed.
2. Apparatus for individual pupils.
3. Apparatus for individuals or small groups working successively.
4. Chemicals.
5. Stock apparatus.
6. Additional desirable apparatus.
7. Pertinent suggestions to the teacher.

The lists are based on a study of twenty-eight state lists, fifteen high-school manuals, one hundred fifteen lists from high schools of large cities, and upon suggestions received from about one hundred fifty individuals. The items have also been compared with catalogs of leading supply houses in order to determine proper specifications for each item.

The names of chemicals have been compared with those in the list prepared by the Committee on Labels (John M. Michener, *Chairman*) and published in the JOURNAL OF CHEMICAL EDUCATION, Vol. VII, No. 12, pp. 2937–42. In most cases we have specified chemically pure material. In the last column of the list of chemicals we have indicated the actual amounts of each chemical needed for a class of eight pupils. These are based upon a careful check of the following manuals: Brownlee, Fuller, and Others; Emory, Boynton, and Miller; McPherson, Henderson, and Fowler; Greer and Bennett; Holmes and Mattern; and Bruce. You will note that in a number of cases one ounce is specified, despite the fact that four ounces may be bought for twice the cost of one ounce. We suggest the purchase of small quantities by high schools in which chemistry is alternated with physics and the class usually has from eight to twelve pupils. The larger amount would undoubtedly be so contaminated by the time chemistry was taught again that most of the better grade chemicals could not be used for work involving tests. In some cases these small schools may even be justified in buying vials of chemicals, as wastage would be considerably less. One pound or one-fourth pound quantities are specified in a few instances, because smaller amounts are not put up by supply houses. This is indicated by an X under 1/4 lb. and 1 oz. columns. For the purpose of comparison we have listed both the cost of the recommended amount with the cost of the next higher amount, and the cost of technical grade or U. S. P. with C.P. Some supplies such as steel wool, baking soda, salt, washing soda, starch, borax, hydrogen peroxide, calcium oxide, and graphite flakes may sometimes be purchased locally at lower cost. In checking the manuals for the chemicals required the Committee finds that several chemicals are specified where one may serve the purposes of the experiment, as zinc nitrate for zinc sulfate and zinc chloride. In order to reduce the number of chemicals required the Committee has made the following substitutions:

Barium chloride for barium nitrate
Carbon tetrachloride for chloroform
Chromium sulfate for chrome alum
Ferric chloride for all ferric salts usually specified
Ferrous ammonium sulfate for all ferrous salts usually specified
Formic acid for oxalic acid
Magnesium sulfate for magnesium chloride or nitrate
Potassium iodide for sodium iodide
Red phosphorus for yellow phosphorus
Sodium chloride for potassium chloride
Zinc nitrate for zinc sulfate or zinc chloride

Prices and specifications are quoted mainly from Catalog H351 of the Central Scientific Company, published in March, 1935. The following comment taken from this catalog is worth noticing carefully. "Catalog prices, like specification, cannot be guaranteed for any definite period of time. Although the prices published in this catalog are substantially current at date of publication, it is inevitable that with the passing of time, changes must occur. It appears at the present writing (March, 1935) that the prices of goods listed in this catalog are at a reasonably stable level, so that the total of the printed prices will approximate the current prices."

The equipment lists include all articles required for the experiments mentioned in the lists prepared by the Senate of Chemical Education and the College Entrance Examination Board. The list of equipment necessary for individual pupils includes only items that are used sufficiently often to warrant their being placed in the

* Presented before the Division of Chemical Education at the ninetieth meeting of the A. C. S., San Francisco, California, August 12, 1935.

pupil's desk. The list of stock apparatus includes reserve stock and material required for demonstration experiments. This list is based on the frequency of occurrence of the items in lists prepared by various state departments of education and lists in six high-school manuals. The Committee recommends that pupils work in groups of two on such experiments as the preparation of hydrogen, oxygen, and carbon dioxide. Such items as flasks, funnel tubes, ringstands, wide-mouth bottles, rubber stoppers, buret clamps, may then be reduced to half the number now specified for a class of eight. Definite specifications have been set down for each item in the list of equipment in order to secure standard size, type, and grade. Consequently, supply dealers to whom the list is submitted for bids will have to bid on identical items. This standardization of type, size, and grade of equipment is in line with the recommendation proposed by the United States Department of Commerce. Incidentally, would it not be advisable for the Division of Chemical Education to recommend to the manufacturers that some steps be taken to standardize on the size of openings in flasks and in wide-mouth bottles and in holes in rubber stoppers in order to avoid the great variety of sizes we now have?

Please note that all items are matched.
No. 5 rubber cork fits 4 oz. bottle and 250-cc. flask.
Holes in corks take 6-mm. tubing.
Funnel tube and glass tubing is 6 mm., outside diameter.
Funnel tube and glass tubing fit holes in rubber stoppers.
Watch glass fits beaker and evaporating dish.
Evaporating dish fits 250-cc. beaker.

The Committee has set down as definite specifications for each item of the list as possible. Adherence to these specifications is absolutely essential if the item which will best serve the needs of the school is to be secured. Too often equipment is purchased in terms of the lowest initial cost, with the result that frequent replacements are necessary. Those responsible for the purchase of equipment need to be educated as to the advisability of considering the initial cost plus the length of useful life of an item. If this is compared with cost of frequent replacement of the cheaper product, the purchaser will find that the article of higher initial price is eventually the cheaper. In fact, cost per year may be considerably less. In order to protect the smaller schools from unscrupulous dealers, it is essential that these institutions be educated to purchase from reliable firms. Perhaps more states may be able to work out some scheme of state aid similar to that of New York State in order to secure durable and essential equipment for various sciences. We need to emphasize that equipment should be purchased in terms of quality. We suggest that the purchaser insist, in almost all instances, on standard American-made articles. Such names as Pyrex, Coor, Exax grade stand for material of known quality. We cannot emphasize too strongly that the better article is ultimately the cheaper.

It is the hope of the Committee that this report will advance education in the field of chemistry by:

1. preventing foolish buying by inexperienced teachers;
2. aiding schools to secure necessary equipment;
3. establishing definite equipment requirements and specifications;
4. establishing definite equipment standards;
5. eliminating dependence upon lists furnished by supply houses;
6. promoting economical buying;
7. demonstrating to boards of education and other purchasing agents the desirability of good equipment;
8. reducing the number of unnecessary accidents in the laboratory.

Please remember that this list is designed primarily for the small high school. High schools with an enrolment of 200 or less include nearly eighty per cent. of the high schools of the United States.

J. H. JENSEN, *Chairman*
E. G. BOWERS HOYT C. GRAHAM
F. C. MABEE J. H. NORTON
C. R. OTTO C. H. STONE
Committee on Minimum Equipment for High-School Chemistry

LIST OF EXPERIMENTS

The list of experiments used in determining chemicals needed for essential experiments is based on the List of Experiments to Accompany the A. C. S. Standard Minimum High-School Course in Chemistry (see JOURNAL OF CHEMICAL EDUCATION, May, 1927, pp. 646–8), and those listed in the following manuals: Brownlee, Fuller and others; Holmes and Mattern; Gray, Sandifur and Hanna; Fletcher, Smith, Harrow, Greer, and Bennett.

1. Heating of metals in air.
2. Weight change on heating a metal.
3. Setting up apparatus.
4. Decomposition of a compound formed by heating a metal in air.
5. Preparation of oxygen.
6. Formation of oxides.
7. Electrolysis of water—demonstration.
8. Decomposition of water by sodium—demonstration.
9. Preparation of hydrogen.
10. Properties of hydrogen—burning hydrogen—demonstration.
11. Distillation of water—demonstration.
12. Solution and suspension.
13. Replacement of hydrogen by magnesium—demonstration.
14. Determination of water of crystallization.
15. Preparation and properties of chlorine—demonstration.
16. Bleaching of cotton—demonstration.
17. Preparation and properties of hydrochloric acid.
18. Test for a chloride.
19. Weight of a liter of oxygen—demonstration.
20. Bases.
21. Neutralization.
22. Titration—demonstration.
23. Forms of sulfur.
24. Preparation of metallic sulfides.
25. Preparation and properties of hydrogen sulfide—demonstration.
26. Sulfur dioxide, sulfite method.

27. Properties of sulfuric acid.
28. Preparation of nitrogen.
29. Determination of the percentage of oxygen in air—demonstration.
30. Preparation and properties of ammonia.
31. Preparation and properties of nitric acid—demonstration.
32. Properties of carbon.
33. Preparation and properties of carbon dioxide.
34. Baking powders.
35. Preparation and properties of carbon monoxide—demonstration.
36. Destructive distillation.
37. Hard waters.
38. Water softening.
39. Action of metals on salt solutions.
40. Double salts.
41. Qualitative separation of lead, silver, and mercury.

ADDITIONAL DESIRABLE EXPERIMENTS FOR WHICH CHEMICALS HAVE BEEN LISTED

1. Types of chemical change: direct combination. Simple decomposition.
2. Types of chemical change. Simple replacement.
3. Types of chemical action. Double replacements.
4. Preparation and properties of nitric oxide. Demonstration.
5. Preparation and properties of bromine. Demonstration.
6. Preparation and properties of iodine.
7. Borax bead tests.
8. Cobalt nitrate tests.
9. Identification of simple salts.
10. Test for iron salts.
11. Action of reducing agent on a ferric salt.
12. Action of an oxidizing agent on a ferrous salt.
13. Iron salts in photography—blue prints.
14. Aluminum hydroxide.
15. Fermentation—demonstration.
16. Preparation of ethereal salts.
17. Soap making.
18. Food constituents: fats. Proteins.
19. Food constituents: carbohydrates.

MINIMUM EQUIPMENT FOR HIGH-SCHOOL CHEMISTRY

Individual Apparatus

NOTE: Percentages as given after each item are taken from a list prepared by T. C. Holy and D. H. Sutton of Ohio State University entitled "Lists of Essential Apparatus for Use in High-School Sciences." The percentages given are based upon the opinions of one hundred forty high-school instructors, sixty-eight heads of science departments and supervisors, and sixteen college instructors. For instance 77 per cent. of this group considered 150-cc. beakers as essential apparatus.

For a Class of 8 Pupils or for 16 Working in Groups of Two

	Unit Price	*Total*	*Considered Essential*
8 Beakers, Griffin low form, with lip, Pyrex glass, 150-cc.	$ .19	$1.52	77%
8 Beakers, Griffin low form, with lip, Pyrex glass, 250-cc. (may be used as water bath).	.20	1.60	81%
24 Bottles, flint glass, wide mouth for cork stopper, uniform neck, 4-ounce, to take No. 5 rubber stopper. Machine made, per doz.	.55	1.10	60%
8 Rubber Stoppers, No. 5. Two-hole, specific gravity 1.20–1.3 holes bored to take 6-mm. glass tubing, (for 4-oz. bottles and 250-cc. flask). (Sp. gr. not safe guide as may add corn oil and lower specific gravity. On heating such corks will lose shape. Better order from a reliable supply house such as Cenco Grey Pure Gum, Waco Red, Fisher, A. H. T. Co.)	.03	.24	87%
8 Crucibles, Porcelain, Coors or Sillimanite, high form, No. 0, 15-cc. capacity.	.15	1.20	89%
8 Crucible Covers, Porcelain, Coors or Sillimanite, for high form crucible, No. 0.	.06	.48	83%
8 Dishes, Evaporating, Coors or Sillimanite, with glazed inside and outside. No. 00-A, 75 mm. dia., 70-cc. capacity.	.18	1.44	94%
8 Flasks, Erlenmeyer, Narrow Mouth, Pyrex glass, 250 cc., to take No. 5 rubber stopper.	.20	1.60	60%
4 Pkgs. Filter Paper, 11 cm. dia., qual. grade. Semi-crepe. 100 sheets to the package.	.13	.52	
8 Funnels, Bunsen Analytic, Pyrex glass, 60° angle, stem 150 mm. long, 65 mm. dia. (Reinforced rim.)	.35	2.80	89%
8 Funnel Tubes, Thistle Top, Pyrex glass stem. 6 mm. dia., straight stem, 30 cm. long.	.15	1.20	94%
24 Glass Plates, 50 × 50 mm. (Cut from scrap window glass and smooth off sharp edges by a few strokes of a file. Some use wet filter paper.)			
4 Vials, Litmus Paper, red. (100 strips per vial.)	.07	.28	
4 Vials, Litmus Paper, blue. (To cut these strips, 1/4 × 2 in. from sheets of litmus paper 8 × 10 in. will require five sheets at 10¢ per sheet. Total: 50¢.)	.07	.28	
8 Stirring Rods, Chemical, of machine-made glass rodding, with ends rounded and fire polished. 6 × 3/16 inch. (May seal up ends of 6-mm. machine-made glass tubing or purchase 1/4 pound of 6-mm. glass rod, lime machine-made, cost about 20¢. Will make 10 stirring rods.)	.04	.32	82%
48 Test-Tubes, Chemical, Pyrex glass, 18 × 150 mm.	.05	2.40	84%
8 Rubber Stoppers, No. 2, one-hole, sp. gr. hole bored for 6-mm. glass tubing (for 19 × 150 mm. test-tube).	.02	.16	71%
8 Test-Tube Brushes, double fan tip, medium for 16-mm. test-tube, galvanized iron wire.	.08	.64	98%
8 Test-Tube Clamp, Cence Bigrip, made of heavy gauge brass spring wire.	.10	.80	95%
8 Watch Glasses, clear, well-annealed glass with edges smoothly ground, rounded edges, 75 mm. dia. (To fit evap. dish and 250-cc. beaker.)	.05	.40	92%
1 Bundle Wood Splints, thin strips of dry wood, 5 1/2 in. long × 1/4 in. wide. 500 in bundle.	.15	.15	
24 Ft. Glass Tubing, lime, machine-made, 6 mm. outside dia., soft glass, lead free, 1 mm. wall.	.015	.36	92%
12 Ft. Rubber Tubing, red, medium wall, 3/16 in. inside dia. Same specifications as rubber stoppers.	.07	.84	
Total for individual apparatus		$20.33	

Desk Apparatus

Equipment to be used in common by two pupils and several successive groups of two, working at the same desk space. This is required in addition to the list of individual apparatus.

	Unit Price	*Total*	*Considered Essential*
24 Bottles, reagent, flint glass, raised lettering, narrow mouth, 4-ounce, per doz.	$4.75	$9.50	
4 hydrochloric acid			79%
4 nitric acid			79%
4 sulfuric acid			79%
4 ammonium hydroxide—rubber stopper			79%
4 sodium hydroxide—rubber stopper			79%
4 bottles, blank			76%
8 Buret Clamps, Bunsen, iron with jaws of pressed steel, japanned, with swivel support clamp, like Cenco Improved.	.30	2.40	77%
8 Burners, alcohol lamps, glass, with metal screw top wick holder, 1/4 in. wick, and metal cap for extinguishing the flame. 8 oz.	.50	4.00	38%
8 Rings, Iron, with Clamp, 3 in. outside dia., with clamp and thumb screw for attaching to support stand. (Serve as support for funnel.)	.18	1.44	94%
8 Supports, Iron, Rectangular Base, 6 3/8 × 4 1/8 inches, rod 18 × 5/16 inches, coppered steel rod. Finished baked, non-chipping enamel.	.40	3.20	94%
8 Test-Tube Racks, like Wilkens and Anderson No. 7536 consisting of hardwood block, oiled finish, with holes bored for 6 test-tubes, 3/4 in. dia., with drying pins.	.55	4.40	95%
8 Triangles, Nichrome, round wire, length of side inside, 2 inches.	.15	1.20	90%

8 Wire Gauze, Galvanized Iron, Asbestos Center, 16 mesh, woven from No. 26 W. and M. gage wire, 4 × 4 inch. Asbestos center pressed in.	.10	.80	95%
Total of Desk Apparatus		$26.94	

Common Pupil Equipment

Equipment to be used in common by two pupils.

To be issued from stock when needed.

NOTE: This material is required for one or more classes in addition to list of individual apparatus and desk apparatus. One set of desk apparatus and one set of this list of apparatus will serve the needs of two or more classes.

	Unit Price	*Total*	*Considered Essential*
4 Cylinders, graduated, student, with spout and broad base. Kimble Kollegiate Graduated 1-cc., 50-cc. capacity.	$ .35	$1.40	68%
4 Deflagrating Spoons, Brass, cup 3/4 in. dia. Total length 15 inches.	.06	.24	76%
4 Dishes, Enameled, flat bottom, dia. about 16.5 cm., capacity, one quart (secure locally).	.15	.60	91%
4 Files, Triangular, slim tapers, single cut, length of cut portion, 5 in.	.10	.40	91%
8 Forceps, Steel, rust-proofed steel, with parts spot welded, length 5 inches.	.08	.64	84%
4 Mortars, Coors or Sillimanite, Porcelain with spout and pestle. Glazed outside but with inside grinding surface unglazed, grinding end of pestle unglazed, 70 mm. dia.	.35	1.40	87%
4 Thermometers, Centigrade, solid, stem, student grade, with engraved scale, graduated one degree divisions and numbered every 10 degrees, −10°C. to 110°C.—single scale. Taylor Instrument Co.	.75	3.00	78%
8 Tubing Clamps, Day's Spring Pinchcock. Heavy spring steel wire finished in nickel plate	.12	.96	72%
Total Common Pupil Apparatus		$8.64	
Total cost of individual apparatus		20.33	
Total cost of desk apparatus		26.94	
Total cost of common pupil apparatus		$8.64	
Total		$55.91	

If gas is available omit alcohol lamps and add the following.

8 Bunsen Burners, like Cenco Maroon for Artificial or mixed gas (Artificial and natural).	.35	$2.80
16 ft. Rubber Tubing, 1/4 in. dia., red, medium wall.	.08	1.44
8 Wing Tops, for Bunsen Burner, brass.	.15	1.20
		$5.44

Cost per pupil: $6.99; if gas is available: $7.17.

CHEMICALS

This List Indicates the Chemicals Needed for a Class of Eight Pupils

(Commonly Used Chemicals Based on Essential Experiments as Proposed by the Division of Chemical Education and Checked against Five of the Commonly Used Laboratory Manuals.)

The column headed "Amount of Chemicals Needed" will serve as a guide in determining the amount of chemicals to order for larger classes and also will be found useful in checking up on the amount of chemicals needed for replacement.

The Committee has listed the cost of larger amounts of chemicals and in some cases technical grade of chemicals for the convenience of those who need to supply chemicals for a larger number of pupils.

In the majority of cases where small amounts of materials are used the Committee has specified chemically pure chemicals.

* Indicates chemicals to be omitted. These are listed for the purpose of price comparison.

† Indicates dangerous chemicals.

.. Indicates chemical not supplied in these amounts, as, acetic acid, 1 oz.

All chemicals meet American Chemical Society (ACS) specifications except where otherwise indicated.

	Cost per Lb.	*1/4 Lb.*	*1 Oz.*	*Amount Needed*
1 lb. Acid, Acetic, ACS Glacial 99.5%	$ .38	.18	..	200 cc.
1 lb. Acid, Nitric, ACS Gr. 1.42	.55	..	..	250 cc.
1/2 lb. Acid, Salicylic, USP crystals	.66	.21	..	..
1 oz. Albumen, Egg, scale (use white of egg)	1.94	.58	.30	1 gm.
1/2 lb. Alcohol, Amyl, pure	.75	.27	..	50 gm.
1 oz. Alizarin, paste, 20%	1.50	.60	.25	3 gm.
1/2 lb. Aluminum Metal, gran., 30-mesh	1.07	.35	..	12 gm.
1 oz. Aluminum Chloride, crystals, ACS	.73	.29	.23	5 gm.
1 lb. Aluminum Ammonium Sulfate, ACS Crystals	.39	.20	..	8 gm.
1 lb. Aluminum Sulfate, tech., ground	.20	..	..	250 gm.
1/2 lb. Ammonium Carbonate, lumps, ACS	.52	.23	..	40 gm.
1/2 lb. Ammonium Molybdate, in Nitric Acid, ACS	.99	.42	..	80 cc.
1/2 lb. Ammonium Chloride, ACS	.45	.21	..	100 gm.
1/2 lb. Ammonium Sulfate, crystals, ACS	.43	.20	..	80 gm.
1 lb. Ammonium Sulfide, light sol., ACS	.48	.34	..	40 cc.
1/2 lb. Antimony, Metal, powder	.56	.27	..	2 gm.
1/2 lb. Barium Chloride, ACS, crystals	.55	.23	..	50 gm.
1 oz. Bismuth Metal, granular, ACS	..	.70	.26	..
1 oz. Bismuth Nitrate Crystals, ACS	2.41	.85	.36	..
†1 oz. Bromine, ACS (use Sodium Bromide)	1.52	.65	.35	8 cc.
1 oz. Cadmium Nitrate, ACS, crystals	1.33	.47	.20	8 gm.
1 oz. Calcium, Metal, turnings	4.30	1.15	.40	8 gm.
1 lb. Calcium Carbonate, marble chips	.20	..	..	175 gm.
1 lb. Calcium Carbide, tech.	.30	..	..	..
1/2 lb. Calcium Chloride, CP, gran. (MCW) 12-mesh for drying tubes	.62	.26	..	80 gm.
1/2 lb. Calcium Chloride, ACS, crystals	.69	.27	..	30 gm.
1 lb. Calcium Fluoride, tech., powder	.20	..	..	16 gm.
12 oz. Calcium Hypochlorite (Bleach. Powder) (recommend high-test Hypochlorite)	..	..	.20	80 gm.
1 lb. Calcium Oxide, in tin container	.20	..	..	200 gm.
1 lb. Calcium Phosphate (Mono basic), tech.	.25	..	..	16 gm.
1 lb. Calcium Sulfate, Gypsum tech.	.20	..	..	16 gm.
1 lb. Carbon Tetrachloride, ACS	.48	.22	..	250 cc.
1 lb. Charcoal, Gran. (Norite)	.30	..	..	24 gm.
1 lb. Charcoal, Wood, lumps	.25	..	..	16 gm.
1 oz. Chromium Sulfate, ACS	1.17	.43	.18	4 gm.
1 oz. Cobalt Nitrate, ACS	2.43	.81	.29	8 gm.
1 lb. Copper Metal, foil, B&S No. 36	.67	.27	..	250 gm.
1 oz. Cupric Nitrate, ACS	.87	.34	.23	4 gm.
1 oz. Cupric Oxide, ACS, wire form	1.78	.61	.25	12 gm.
*1/2 lb. Cupric Oxide, tech., powder	.56	.22	..	..
1/2 lb. Cupric Sulfate, ACS, crystals	.52	.22	..	16 gm.
*1 lb. Cupric Sulfate, tech.	.23	..	..	..
1 oz. Cupric Bromide, ACS, crystals	2.02	.73	.34	8 gm.
1 lb. Dextrose, pure, gran. (use corn sirup)	.30	..	..	8 gm.
1/2 lb. Haines Solution (use instead of Fehling Solution)	1.50	.50	.25	100 cc.
1 lb. Hydrogen Peroxide, 3% USP	.29	.17	..	144 cc.
1 oz. Iodine, USP, resublimed	2.86	.86	.39	4 gm.
1 lb. Iron Metal filings, fine, clean, 30-mesh	.22	..	..	270 gm.
1/2 lb. Ferric Chloride, ACS, lumps	.44	.21	..	24 gm.
*1 lb. Ferric Oxide, tech.	.30	..	..	8 gm.
1/2 lb. Ferric Oxide, ACS	.62	.27	.19	..
*1 lb. Ferrous Sulfate, tech.	.20	..	..	..
1 lb. Ferrous Ammonium Sulfate, ACS (suggest instead of Ferrous Sulfate—keeps better)	.52	.22	..	..
1 lb. Ferrous Sulfide, small lumps	.20	..	..	200 gm.
1/2 lb. Ether, USP, Squibb (Ethyl ether)	.44	.20	..	..
1/2 lb. Lead, Metal, pure, gran.	.46	.20	..	8 gm.
*1/2 lb. Lead, Metal, tech., tea lead	.30	.25	..	..
1 sq. ft. Lead sheet, 1/32 in. thick	..	..	.75	..
1/2 lb. Lead Acetate, ACS	.52	.23	..	12 gm.
*1/2 lb. Lead Acetate, tech., gran.	.35	.20	..	..
1/2 lb. Lead Nitrate, ACS	.75	.30	..	30 gm.
*1/2 lb. Lead Nitrate, tech.	.45	.20	..	..
1/2 lb. Lead Monoxide, ACS	.44	.21	..	24 gm.
*1/2 lb. Lead Monoxide, tech.	.33	.20	..	..
1/2 lb. Lead Oxide, red lead, powd., tech.	.35	.20	..	..
1/2 lb. Lead Peroxide, tech., brown	.65	.25	..	..
1 oz. Lithium Nitrate, ACS	2.86	.94	.31	4 gm.
1 oz. Litmus Cubes, ACS	1.26	.40	.20	..
1 oz. Magnesium, Metal, ribbon	..	1.72	.45	32 gm.
1 oz. Magnesium, Metal, powder	..	.90	.30	20 gm.
1 lb. Magnesium Sulfate, USP, crystals	.17	..	..	8 gm.
*1/2 lb. Magnesium Sulfate, ACS	.42	.20	..	..
1/2 lb. Manganese Dioxide, ACS, powder	1.13	.42	..	50 gm.
*1 lb. Manganese Dioxide, tech.	.22	..	..	..
1 lb. Mercury, Metal, ACS, redistilled	2.45	.80	..	24 gm.
1 oz. Mercuric Nitrate, ACS	3.12	1.07	.43	4 gm.
1 oz. Mercurous Nitrate, ACS	3.19	1.08	.43	4 gm.
1/2 lb. Mercuric Oxide, pure, red, USP	1.99	.58	.25	24 gm.
1 oz. Methyl Orange	4.82	1.51	.47	..
1/2 lb. Nickel metal powder, tech.	1.25	.42	..	..
1/2 lb. Oil, cottonseed	.40	.20	..	120 gm.
1 oz. Phenolphthalein, USP	1.09	.36	.18	..
1/2 lb. Phosphorous, Amorphous, red	.90	.35	.25	12 gm.

*½ oz. Potassium, Metal, balls	..	..	1.40	..
¼ lb. Potassium Bichromate, ACS	.75	.30	.19	4 gm.
*¼ lb. Potassium Bichromate, tech., crystals	.35	.20	..	..
¼ lb. Potassium Hydrogen Tartrate, USP	.35	.25	..	8 gm.
¼ lb. Potassium Bromide, USP	.64	.21	..	24 gm.
¼ lb. Potassium Chromate, ACS, crystals	.78	.31	..	..
1 lb. Potassium Chlorate, ACS, crystals	.57	.25	..	170 gm.
*1 lb. Potassium Chlorate, pure	.33	..	..	..
1 oz. Potassium Ferricyanide, ACS, crystals	1.25	.44	.26	8 gm.
1 oz. Potassium Ferrocyanide, ACS, crystals	1.12	.40	.23	12 gm.
1 lb. Potassium, USP, pellets	.69	.26	..	200 gm.
1 oz. Potassium Iodide, USP	2.04	.59	.25	4 gm.
¼ lb. Potassium Nitrate, ACS, crystals	.51	.29	..	4 gm.
*1 lb. Potassium Nitrate, tech.	.29	..	..	..
¼ lb. Potassium Permanganate, USP	.50	.18	..	2 gm.
¼ lb. Potassium Sulfate, ACS, crystals	.55	.29	..	4 gm.
*1 lb. Potassium Sulfate, pure, crystals	.35	..	..	..
1 oz. Potassium Thiocyanate, ACS	1.40	.49	.26	12 gm.
¼ lb. Rose's Metal	..	.80	.30	..
½ lb. Silver Nitrate, ACS	10.61	2.70	.75	90 gm.
¼ lb. Soap, Castile, powder	.70	.35	..	8 gm.
= ¼ lb. Sodium, Metal	.88	.35	..	12 gm.
¼ lb. Sodium Acetate, ACS	.52	.22	..	8 gm.
*1 lb. Sodium Acetate, tech.	.30	..	..	..
1 lb. Sodium Hydrogen Carbonate (baking soda), pure	.14	..	..	40 gm.
1 lb. Sodium Hydrogen, Sulfite, tech.	.34	..	..	80 gm.
¼ lb. Sodium Benzoate, USP, powder	.83	.26	..	..
1 lb. Sodium Borate, pure, cryst. (borax)	.20	..	..	32 gm.
1 lb. Sodium Carbonate, tech., crystals (washing soda)	.20	..	..	80 gm.
*1 lb. Sodium Carbonate, ACS, anhyd.	.46	.21	..	..
1 lb. Sodium Chloride, pure (rock salt)	.20	..	..	500 gm.
1 lb. Sodium Hydroxide, ACS, pellets	.65	.27	..	120 gm.
1 lb. Sodium Thiosulfate, pure, cryst.	.20	..	..	16 gm.
¼ lb. Sodium Nitrate, ACS, crystals	.43	.20	..	20 gm.
*1 lb. Sodium Nitrate, pure	.25	..	..	..
¼ lb. Sodium Nitrite, ACS	.61	.26	..	20 gm.
¼ lb. Sodium Monohydrogen Phosphate, ACS	.47	.21	..	2 gm.
*1 lb. Sodium Monohydrogen Phosphate, tech.	.25	..	..	..
¼ lb. Sodium Dihydrogen Phosphate, ACS	.66	.27	..	2 gm.
1 lb. Sodium Sulfate, tech., cryst.	.27	..	..	24 gm.
¼ lb. Steel Wool	.50	.25	..	16 gm.
1 oz. Strontium Chloride, ACS	.74	.30	..	4 gm.
*¼ lb. Strontium Chloride, pure, cryst.	.40	.20	..	..
1 lb. Sulfur, roll	.20	..	..	280 gm.
¼ lb. Tin, Metal, pure, gran.	1.35	.39	..	24 gm.
¼ lb. Wood's Metal	3.00	1.00	.50	..
¼ lb. Zinc, Metal, ACS, gran.	.60	.26	..	420 gm.
1 lb. Zinc, Metal, tech., gran.	.25	..	..	..
¼ lb. Zinc Nitrate, ACS	.78	.31	..	16 gm.
¼ lb. Zinc Sulfate, ACS	.43	.20	..	8 gm.
*1 lb. Zinc Sulfate, tech., cryst.	.23	..	..	

	Cost per Bottle	*Lb.*	*Amount Needed*
6 lb. Acid, Hydrochloric, ACS, sp. gr. 1.18	1.38	.49	2250 cc.
*6 lb. Acid, Hydrochloric, tech.	1.20	..	...
9 lb. Acid, Sulfuric, ACS, sp. gr. 1.84	1.98	.50	3000 cc.
*9 lb. Acid, Sulfuric, tech.	1.44	.47	...
4 lb. Ammonium Hydroxide, ACS, sp. gr. 0.90	1.28	.56	800 cc.

	Per Qt.	*Per Gal.*
1 qt. Alcohol, denatured (order 1 gallon of alcohol if alcohol lamps are used)	.45	1.10
1 qt. Alcohol, Methyl, absolute	.45	1.10

Total cost of chemicals $43.32

The following bottles have an approximate capacity of 2500 cc.:
4 lb. bottle Ammonium Hydroxide
6 lb. bottle Hydrochloric Acid
9 lb. bottle Sulfuric Acid

Metric Equivalents:
1 pound is equivalent to 454 grams
¼ pound is equivalent to 113 grams
1 ounce is equivalent to 28 grams

Such items as the following may be secured locally: baking soda, borax, butter, clay, cloth (silk, wool, cotton, rayon), calcium oxide (quicklime), glucose (corn sirup), glycerine, lard, plaster of paris, rock salt, salt (table), starch, steel wool, sugar, vinegar (acetic acid, white), washing soda, water glass (sodium silicate).

General Apparatus

This includes items for instructors' use and items to replace breakage of pupil apparatus.

Items marked x allow for student breakage.

		Unit Price	*Total*
1	Balance, Cenco Tripple Beam, Agate Bearing No. 2640 or equivalent	..	$17.50
1	Bead Wire, Platinum, No. 28 wire (large class use chromel wire)	.35	.35
x2	Beakers, Griffin low form, with lips, Pyrex glass, 150-cc.	.19	.38
x2	Beakers, Griffin, low form, with lip, Pyrex glass, 250-cc.	.20	.40
2	Beakers, Griffin, low form, with lip, Pyrex glass, 400-cc.	.26	.52
2	Burets, Mohr's, for Pinchcock, Exax grade, Blue Line	.60	1.20
1	Buret Clamp, Bunsen, Iron with jaws of pressed steel, japanned, with swivel support clamp like Cenco Improved	1.50	1.50
12	Candles, 12S, Paraffin	.25	.25
1	Clamp, Universal, Swivel Jaw, Rubber covered, for tube up to 2 inches in diameter	.70	.70
1	Clamp Holder, for fastening clamp to support rod, to take rod up to 9/16 inches in diameter	.25	.25
1	Condenser, Liebig, lime glass, with rubber stopper connections, and adapter top, length of jacket, 30 mm.	.80	.80
1	Conductivity of Solutions Apparatus, Cenco No. 81180	1.50	1.50
4	Oz. Copper wire, soft No. 24	.30	.30
1	Cork Borer, Single Brass, for drilling holes for 6 mm. tubing, swedged and soldered with punch	.25	.25
1	Cylinder, Double Graduated, Exax, with spout and broad base, Graduated, 5 cc.–500-cc. capacity	1.50	1.50
1	Electrolysis Apparatus, Cenco No. 81190, Improved Form, with platinum electrodes	6.25	6.25
2	Pkg. Filter Paper, 11 cm. diameter, quality grade, semi-scope, 100 sheets to the pkg.	.13	.26
1	First Aid Cabinet, Cenco	6.00	6.00
2	Flasks, Erlenmeyer, narrow mouth, Pyrex glass, 250-cc. to take No. 5 rubber stopper	.20	.40
1	Flask, Erlenmeyer, narrow mouth, Pyrex glass, 500-cc.	.25	.25
2	Funnels, Bunsen Analytic, Pyrex glass, 60° angle, stem 150 mm. long, 65 mm. dia., reinforced rim	.35	.70
2	Funnel Tubes, Thistle Top, Pyrex glass, stem 6 mm. diameter, straight stem 30 cm. long	.15	.30
1	lb. Glass Tubing, Lime, machine made, 6 mm. outside diameter, soft glass, lead free	.55	.55
3	Boxes Labels, rectangular, red border, Dennison No. 261	.10	.30
2	Lead Dishes, 75 mm. diameter	.12	.24
2	Magnets, bar, black finish, 15 cm. long, 10 × 10 mm. cross-section	.25	.50
1	Magnifier, Tripod, Cenco No. 60020	.75	.75
1	Pipet, Measuring Pipet, Mohr, student grade Kimble Kollegiate, 25-cc., graduated 1/10-cc.	.60	.60
1	lb. Paraffin, ordinary	.20	.20
1	Plate Mervin Color Screen for flame test of the elements (use for class of 8)	.80	.80
1	Retort, Tabulated, with glass stopper, Pyrex brand, 125-cc. capacity	1.80	1.80
1	Ring, Iron, with clamp, 4 inch outside diameter, with clamp and thumb screw for attaching to support stand (serve as support for funnel)	.20	.20
2	Rubber Stoppers, No. 5, two-hole, specific gravity 1.20 to 1.30, holes bored to take 6 mm. glass tubing	.03	.06
2	Rubber Stoppers, No. 2, one-hole, sp. gv. 1.2 to 1.3, hole bored for 6 mm. glass tubing, for 18 × 150 mm. test-tube	.02	.04
12	Ft. Rubber Tubing, red, medium wall, 3/16 inch inside diameter	.07	.84
2	Sand Baths, steel, shallow form, 4 inch diameter, Armco Iron	.08	.16
x12	Test-Tubes, Chemical, Pyrex glass, 18 × 150 mm.	.05	.60
1	Test-Tube Clamp, Cenco Bigrip, made of heavy gage brass spring wire	.10	.10
2	Vials Test Paper, Litmus Paper, Red (100 strips per vial)	.07	.14
2	Vials Test Paper, Litmus Paper, Blue (100 strips per vial)	.07	.14
1	Tube Test Paper, Turmeric Paper, 100 strips	.07	.07
1	Tube Test Paper, Potassium Iodide Starch Paper, 100 strips	.10	.10
1	Tongs, Crucible, Brass Double Bent with riveted joint, length 9 inches	.25	.25
x4	Watch Glasses, clear, well-annealed glass with edges smoothly ground, rounded edges, 15 mm. thick	.05	.20
1	Sq. ft. Zinc Sheet, 1/32 thick	.45	.45

General Apparatus. Total	50	50.65
Individual Apparatus for eight pupils		55.91
Chemicals		43.32
Grand Total		149.88
Total Cost per Pupil		18.74

The following items may be secured locally: candles, claw-hammer, dry cells, glass cutters, jars for waste, paper shears, pliers (side cutting), screw driver (6-inch blade), soldering outfit, thread (cotton No. 50), tinner's shears.

Allow about 10% for breakage, estimated.
Renewal cost per pupil per year, estimated about $0.50.
Each pupil is expected to furnish his own laboratory apron, cloth for cleaning desk, soap, matches, and cleaning powder.

ADDITIONAL DESIRABLE APPARATUS

		Price
1	Air Pump, Vacuum and Pressure, with foot stirrup	$ 4.50
1	Air Pump Plate, Iron, 20 cm. diameter	6.50
1	Barometer, Mercurial, Cenco Improved, No. 76980	25.00
1	Bell Jar, extra high form, for barometer tube	5.00
2	Boats, Combustion, Coors or Sillimanite, 88 mm. long by 12 mm. wide	.50
12	Bottles Tincture, hand-made, flint glass, flat stoppers, round, 125-cc.	4.15
2	Bottles, Milk-Test, for Babcock Tester	.56
2	Bottles, Cream-Test, for Babcock Tester	.76
1	Boyle's Law Apparatus, Cenco Ahrens, No. 76405	20.00
1	Brownian Movements Apparatus	4.00
1	Trough, Glass Pyrex, No. 231, Utility Dish—10½ × 6½ × 2"	.75
1	Brush, milk-test bottle	.05
1	Brush, cream-test bottle	.11
1	Burner, Fisher	2.00
1	Pair Carbon Electrodes use with Electrolysis Apparatus	.50
1	Cell, Gotham Demonstration, Cenco No. 79325	4.50
1	Chart, Metric System	2.25
1	Chart, Periodic, Welsh	...
6	Connector Clips, like Cenco No. 1072	1.50
1	Distilling Flask, Pyrex glass, 250-cc.	.55
3	Dry Batteries, Eveready No. 6 (secure locally)	.90
1	Electroscope, with Metal Case and New Metallic Leaf	1.75
1	Pkg. Filter Paper, Quality grade, semi-crepe, 100 sheets per pkg. 18½ cm. diameter	.35
1	Flask, Filtering, heavy wall, with Tubulature, Pyrex brand, 250 cu. cm.	.70
1	Exciting Pad, flannel, 20 × 25 cm.	.25
1	Exciting Pad, silk, 20 × 25 cm.	.40
1	Friction Rod, glass, 25 cm. long × 1 cm. in diameter	.30
1	Friction Rod, vulcanite, 25 cm. long × 10 mm. in diameter	.35
1	Funnel, Bunsen, general laboratory, lime glass, 125 mm. diameter	.48
2	Gas Measuring Tubes, Exax Blue Line, 100-cc.	2.80
1	Gas Generator, Kipp, 500-cc.	10.00
2	Glass Tubing, Combustion, Pyrex brand, standard wall, 15 mm. outside diameter, 20 cm. long—estimated	.50
1	Heater, Cenco, hot cone, electric, 110-v.	6.50
1	Hydrometer, Bé. and sp. gr., Heavy Liquid, Plain, Laboratory Grade, length 12 inches	.50
1	Hydrometer, Bé. and sp. gr., Light Liquid, Plain Laboratory Grade, length 12 inches	.50
2	Hydrometer Jars, with plain rim, lime glass, 12 × 2 in.	1.01
1	Battery Hydrometer, Syringe Type with Thermometer	1.00
2	Chimneys, Student's Lamp, Length, 10⅞ in.; base diameter, 1⅞ in.; top diameter, 1¼ in.	.50
1	Humidiguide (Indicating Hygrometer), Tycos	5.00
1	Liter Block, Hardwood, Loaded	4.50
1	Liter Case, Cenco, cast aluminum sides, one side glass with etched graduations in millimeters	6.75
1	Microscope compound, 1 ocular 10x and double nosepiece with 16 mm. and 4 mm. objectives	71.75
1	Mortar and Pestle, Iron, pint size, vase form	1.40
1	Pipet, Cream Test, Exax, for Babcock test, 18-cc.	.30
1	Pipet, Milk Test, Exax, for Babcock test, 17.6-cc.	.30
1	Deflagration Holder for Sodium, consists of two hemispherical, perforated brass bowls, 30 mm. diameter	.55
1	Soil Acidity and Alkalinity Test, La Motte-Kenny	5.00
1	Battery, Edison Storage, Ni-Iron-Alkal. type, Type B1H	6.70
1	Support, Test-Tube, Hardwood, Twelve Tube	.50
1	Thermometer, Solid Stem, Student Grade, −5 to 360	1.30

PERTINENT SUGGESTIONS TO SCIENCE INSTRUCTORS

*Precautions to Be Observed in the Handling and Use of Chemicals**

The Instructor

1. All inflammable, explosive, poisonous, or otherwise dangerous chemicals should be stored separately under lock and key and access to them should be had only by a limited number of thoroughly informed and responsible persons.

2. Some check should be made on chemicals issued to students to insure against pilfering for improper use.

3. Special care should be exercised to insure against accidents from particularly dangerous chemicals, such, for example, as yellow phosphorus (be sure the sticks are always completely covered with water and the container so sealed as to prevent evaporation), metallic sodium or potassium (be sure they are always protected against contact with moisture), potassium cyanide (be sure to protect from moisture and consequent evolution of deadly hydrocyanic acid fumes), carbon bisulfide (be sure that the container is so sealed as to prevent evaporation).

4. Special care should be exercised to insure accurate labeling of all chemicals issued to students or used in the laboratory.

5. Always provide and insist on the use of earthenware jars of adequate size as receptacles for chemical wastes of all kinds.

6. There should be at hand at all times in every chemical laboratory, a liberal supply of sand with which to smother small laboratory fires as well as for use in sand baths.

7. Several small fire extinguishers should also be at hand at different points in a laboratory for emergency use.

8. Do not purchase or requisition cheap chemicals or other laboratory supplies. The best materials, whether chemicals or equipment, from a reliable source, together with proper instruction and supervision, is the best and cheapest insurance against accident.

The Student

1. In general, all acid and alkali reagents, especially in concentrated form, are caustic and dangerous. Therefore, extreme care should always be exercised in handling them.

2. Never mix reagents of other chemicals except under definite instructions from those in charge.

3. Proper methods of handling reagent bottles and their stoppers when pouring reagents, as well as the proper handling of dry agents, to avoid sloppiness and consequent danger, should be carefully described, emphasized, and demonstrated.

4. Concentrated sulfuric acid is one of the ordinary laboratory reagents. The wrong method of diluting it, in test-tubes or other containers, has caused many a blinded eye, or a burned face, or ruined clothing, or all three. Never Pour Water on Concentrated Sulfuric Acid. Always Pour the Concentrated Sulfuric Acid Slowly on the Water.

5. Never put chemicals in the pockets of clothing of any kind, either as a joke or for any other reason—otherwise ruined clothing, personal injury, or a general fire may be the result.

6. Because many chemicals and laboratory fumes attack and ruin jewelry, students should be warned not to wear jewelry during laboratory work.

7. When accidents do occur—regardless of their nature or cause—students should immediately call for assistance from those in charge.

SUGGESTIONS ON STORING CHEMICALS

1. Do Not Store Chemicals Where Fumes from Them Can Get at Balances or Other Apparatus with Metallic Parts; otherwise the fumes will soon ruin the apparatus. These two classes of material should be in separate rooms, if possible.

2. Preparation of Shelves. The individual bottles on shelves should be separated by ¼ to ⅜ inch. This can be accomplished by tacking strips of half-round molding on the shelves—one strip between adjacent bottles. This prevents the accidental knocking down of adjacent bottles when the one between is taken down.

3. Current stock of acids should be placed on the lowest shelves and grouped as in any good catalog.

4. After the acids the chemicals should be arranged in alphabetical order according to chemical name (unless some other grouping is preferred).

5. Organics and inorganics should be in separate major groups. C.P. and technical grades should not be separated but stored together.

* From Pamphlet HSC, February, 1930, Central Scientific Co.

6. Shelving should be divided into groups with subdivision numbers (or letters) for use in index.

7. Access to current shelves by student should be regulated by definite enforced rules. Access to reserve stocks should be restricted to instructor and student assistants. The instructor should always accompany student assistants to the reserve stock.

8. You should be thoroughly acquainted with the procedure to use in case of accident. Have your first-aid kit in a convenient place and know how to use it. Secure copy of Laboratory Emergency Chart—Fisher Scientific Co., Pittsburgh, Pa. Also copies of laboratory poster on accident prevention, National Safety Council, 168 North Michigan Avenue, Chicago, Illinois.

9. It is impossible to set down air-tight specifications for each item. Hence the need of dealing with reputable supply houses.

CORRESPONDENCE

THE IDEAL PROFESSOR OF CHEMISTRY IN THE SMALL COLLEGE

To the Editor

DEAR SIR:

This article impressed me at first reading in the same way that I am impressed when I look at the composition of a crazy quilt. As a crazy quilt is made up of crazy patches so is this article made up of patches (ideals) collected from a wide range of accrediting agencies.

The writer seems to give one the impression that an ideal is something at which one is to poke fun. Then he makes a distinction between the ideal professor in the "small" college and his "academic brother" in the "great university." He leads one to question the wisdom of ever allowing an ideal to gain a foothold in the brain of him who ventures to cast his lot and his fortunes in that much misunderstood and little appreciated institution, the "small" college. "Still the wonder grew that one small head contained all he knew," was said of the village school master by the poet, who was also poking fun at the poor benighted pedagogue. There seems to be the cry of despair all through this article that this much laughed at, misguided, misdirected idealist, who is still hunting for the pot of gold at the foot of the rainbow, should aspire to achieve all of the virtues listed from *A* to *I* with subdivisions 1–5 under *B* and 1–6 under *F* and 1–3 under *I* and last, but almost forgotten, to "still find time for his family and social obligations." The entire article ends with the fervent prayer, "AMEN," which signifies "So it is; or so be it; let it be so; would that it were so." One is given the further impression that the commendable virtues listed as appertaining to and required of the ideal professor of the "small college" are not to be considered a part of the requirements of his academic brother in the "great university," yet by his use of the term "academic" he assumes that all of the virtues listed as ideals for the "teacher" in the small college are taken for granted or are included in the term "academic." In other words, it is assumed that the "academic brother" is a "Simon pure" scholar while the "teacher in the small college" (with emphasis on the word *small*) has to be prayed for in order that he may arrive at that state of perfection. The "teacher" in the small college is further complimented by the statement that his duties "are considerably more varied and extensive than those of his academic brother in the great university (emphasis on the much over-worked word *great*). The unfortunate "doctor of philosophy" who has obtained all of his higher education in a large institution certainly gives the "large" or the "great" university some very bad advertising when he finds himself a misfit in the congregation of the "ideal professors." It raises the question as to whether his education is high or low or whether it is education at all.

This article also may have a tendency to intensify prejudices and misunderstandings between the small college and the great university. The small college was once described as a log with a student on one end and Mark Hopkins at the other end. Presumably the log, the student, and Mark were all composed of scholastic timber and all were idealists.

Now to go from jest to earnest the writer has been a member of the small college for the past twenty-three years and has had abundant opportunity to associate with his brethren who have cast their lots with the larger universities. He has been able to do about everything listed as ideals for the teacher in the small college and finds that his brethren in the large universities in many cases have just as many "outside calls" to serve humanity as are thrust upon the teacher in the small college. The phenomenal thing is that so many men in the profession of teaching and of learning chemistry find time to do so many different things and to do them so well.

If I may add two ideals to the commendable list of ideals already assembled, then will we all have something to shoot at which is worth while. The first ideal, and I would have it marked (A), would be for the chemist to learn how to preserve and to conserve his physical health. It does not speak very well for the profession of chemistry to have so many chemists' names apear in the column in the News under NECROLOGY as having died from heart or some of the diseases of disintegration while yet comparatively young men. With all of our knowledge of chemistry and chemical laboratories we seem to be quite ignorant

about the regulation and control of the chemical processes of the human body. We control states of equilibrium in the laboratory but not in our physical bodies. The second ideal which needs to be strongly recommended to the ideal chemist is to have an ideal of some sort which is as large or larger than the one outlined under *I*, p. 202, JOURNAL OF CHEMICAL EDUCATION, **13**, May, 1936.

GEORGE W. MUHLEMAN

HAMLINE UNIVERSITY
SAINT PAUL, MINNESOTA

THE MOLECULAR WEIGHT OF RACEMIC ACID

To the Editor

DEAR SIR:

During the course of some theoretical work on the optical isomerism of tartaric acid the writer found that racemic acid was yielding results only half of that expected and given by the (*d*) and (*l*) forms of the acid.

Compounds possessing two asymmetric but structurally similar carbon atoms, of the general formula C_{abc}—C_{abc} exist in three different configurations. Two of these spatial arrangements are optically active and opposite in sign (antipodes). The third is represented by an internally compensated structure and cannot be resolved into active components (*meso* form). A fourth compound, the racemic form, is produced by the union of the two active enantiomorphs and can be resolved or separated into its optically active components by special methods.

A paradigm may help in elucidation. Let each of the two asymmetric carbon atoms be represented by *A* and their different spatial configurations by the signs + and − . The following arrangements are possible.

(1)	(2)	(3)	(4)	(5)
$+A$	$-A$	$+A$	$-A$	$\left[\binom{+A}{+A} + \binom{-A}{-A}\right]$
$+A$	$-A$	$-A$	$+A$	

Figures (1) and (2) represent respectively the (*d*) and (*l*) forms of tartaric acid. Figures (3) and (4) are identical and represent the (*i*) or *meso* form of tartaric acid. These three compounds have each a molecular weight of 150.05. Figure (5) represents *dl*-tartaric acid or racemic acid. With a little thought it will be realized that its molecular weight must be *twice* that of the other forms of tartaric acid, not including the water of crystallization usually associated with it.

Schmidt and Rule (*1*) in reference to racemic acid say, "The crystalline acid has the composition $2C_4H_6O_6 + 2H_2O$." Bernthsen and Sudborough (*2*) likewise plainly state this fact. However, Richter (*3*), Olsen (*4*), Hodgman (*5*), the "International Critical Tables" (*6*), and Mulliken (*7*) state that the molecular weight of racemic acid with one molecule of water is 168.07.

That this has proved very confusing not only to the writer but to numerous other workers can be definitely shown.

In 1933, Dr. A. K. Anderson, under whom the writer once had the pleasure of studying physiological chemistry, published in collaboration with A. H. Rouse and T. V. Letonoff a paper [*Ind. Eng. Chem., Anal. Ed.*, **5**, 19 (1933)] entitled, "A Colorimetric Method for the Determination of Tartaric Acid." The method is of distinct value in the analysis of tartrate baking powders and can be used in the presence of aluminum. The following paragraphs from this paper are of interest.

> As a matter of interest the application of the colorimetric method to the determination of other forms of tartaric acid was studied. Using *d*-tartaric acid as a standard, it was found that *l*-tartaric acid, *l*-ammonium tartrate, and *meso*-tartaric acid produce a color equivalent to that of the standard. With racemic acid the color intensity was approximately one-half that of the standard.
>
> This reaction of racemic acid was surprising. It was thought that possibly there might be some union of the *d*- and *l*- forms in racemic acid which was causing an interference in the reaction, but molecular weight determinations by the freezing-point method indicate no such union. With regard to the purity of the racemic acid used (obtained from the Eastman Kodak Company) it may be said that it was optically inactive and that it required the theoretical amount of sodium hydroxide for neutralization. The melting point was 202°C., whereas the accepted value is 205–206°C. A mechanical mixture of equal parts of *d*- and *l*-tartaric acids did not react like racemic acid but gave the proper color intensity. Two different samples of racemic acid were analyzed with identical results. No satisfactory explanation can be made for this behavior of racemic acid.

In view of the foregoing statement that racemic acid should be represented by the formula $2C_4H_6O_6 + 2H_2O$ and not $C_4H_6O_6 + H_2O$ as given in all the standard sources of information, little need be added in explanation of the apparent discrepancy in the colorimetric analysis of racemic acid except to point out that this communication helps to substantiate the essential accuracy of the work reported by Dr. Anderson and his collaborators.

EUGENE W. BLANK

COLGATE-PALMOLIVE-PEET COMPANY
JERSEY CITY, NEW JERSEY

LITERATURE CITED

(1) SCHMIDT AND RULE, "A textbook of organic chemistry," 2nd ed., D. Van Nostrand Co., Inc., New York City, **1932**, p. 281.
(2) BERNTHSEN AND SUDBOROUGH, "A textbook of organic chemistry," new edition, D. Van Nostrand Co., Inc., New York City, **1922**.
(3) RICHTER AND SPIELMANN, "Organic chemistry," Vol. 1, 2nd ed., P. Blakiston's Son & Co., Philadelphia, Pennsylvania, **1919**, p. 601.
(4) J. C. OLSEN, "Van Nostrand's chemical annual," Sixth Issue, D. Van Nostrand Co., Inc., New York City, **1926**.
(5) C. D. HODGMAN, "Handbook of Chemistry and Physics," Chemical Rubber Publishing Co., Cleveland, Ohio, 19th ed., **1934**, p. 686.

(6) "International critical tables," Vol. I, McGraw-Hill Book Co., Inc., New York City, **1926**, p. 186.
(7) S. P. MULLIKEN, "Identification of pure organic compounds," Vol. 1, John Wiley & Sons, Inc., New York City, **1905**, p. 50.

PREPARATION OF HYDROBROMIC ACID SOLUTION OF CONSTANT BOILING POINT

To the Editor

DEAR SIR:

I was interested in the paper by G. B. Heisig and E. Amdur in your issue for April, 1937, pp. 187–8, on the preparation of hydrobromic acid in solution, from potassium bromide and sulfuric acid. The authors were good enough to mention the modification I introduced into Pickles' method, using stannous chloride to reduce any free bromine liberated in the reaction.

I have made enquiries among British chemistry teachers and find the method is widely used in this country. As given in the original paper the method has the disadvantage that it introduces some hydrochloric acid into the distillate, but I have not observed any sulfuric acid in the hydrobromic acid so prepared, nor, for that matter, stannous or stannic sulfides. Sulfur has been known to appear in the condenser, and should any reach the receiver it could be removed by filtration. As little as 0.01 g. stannous chloride is adequate for addition to 30 g. of *pure* potassium bromide in 50 cc. of distilled water for treatment with 20 cc. of *pure* sulfuric acid. I am informed that metallic tin itself can be used (to avoid any HCl in the HBr) but I imagine this could introduce sulfur or hydrogen sulfide into the distillate and I prefer the addition of a *trace* (not more than 0.04 per cent.) of sodium sulfite to the bromide.

The hydrobromic acid obtained boils constantly between 124°C. and 126°C. according to the pressure, and although the liquid distilled may become orange yellow in color, no free bromine passes into the receiver and the distillate remains quite colorless. Although I still incline to the use of a trace of some reducing agent in this reaction, I should like to congratulate the authors upon having found what seems to be the most convenient method of making hydrobromic acid solution of constant b. p.

GERALD DRUCE

56, BISHOPS PARK RD.
NORBURY, S.W. 16, ENGLAND

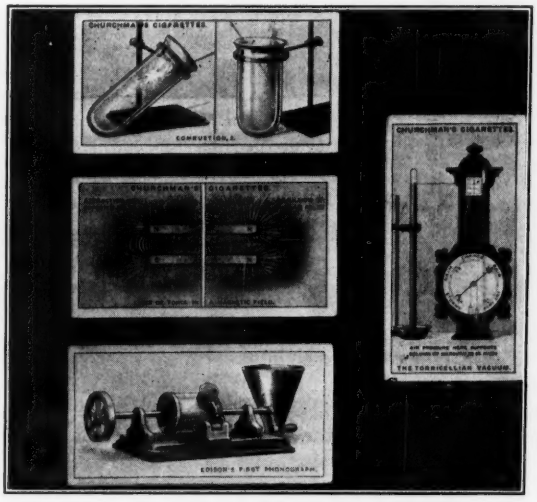
CIGARETTE CARDS AND CHEMISTRY

To the Editor

DEAR SIR:

Collateral material dealing with the various branches of chemistry is to be found everywhere for the seeking. Thus in the pages of THIS JOURNAL several articles have recently appeared showing the relation of chemistry to everyday life and objects.[1,2]

The writer has long been interested in chemistry as reflected by philately, numismatics and press clippings, but in these studies no reference to chemistry and cigarette cards has ever been found. Perhaps the fact that cards are no longer packed with domestic cigarettes has caused them to be overlooked and neglected as



a source of chemical information. Cigarette cards are very apt to be dismissed with an indulgent smile as fit playthings for juveniles, but card collecting is indulged in by many serious adult collectors and is enjoying great popularity on the continent of Europe with the natural consequence that many of the older sets are now selling at a premium.

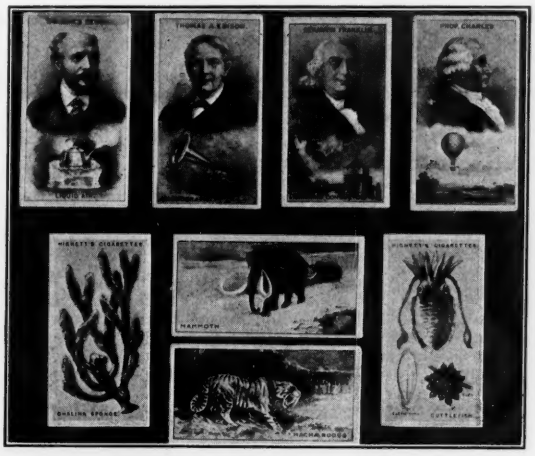
Originally cards were simply plain pieces of cardboard put in to stiffen a paper packet of cigarettes and bore neither print nor picture. In the trade cigarette cards are still known as "Stiffeners."

In 1887 the first advertisement appeared, being printed in red and black. Following this came pictured advertisements, but it was not until 1895 that the first true pictures arrived in the form of a set of ships. However, in this set there was no printed information on the reverse side of the card, and it was not until a year later, in 1896, that a set was issued having both a pictorial front and informative back.

Figures 1 and 2 show reproductions of several biological and chemical cards from the writer's collection. Sets are available on almost every conceivable subject. A recent catalog listed well over one thousand different sets. Biological subjects are especially prolific in both number and variety. Among the cards of

[1] H. F. SCHAEFFER, "Philately serves chemistry," J. CHEM. EDUC., **11**, 259 (1934).
[2] J. CUSHMAN, "Sources of pictures," *ibid.*, **13**, 328 (1936).

most interest to chemists are such as inventors, famous scientists, interesting experiments, optical illusions, scientific inventions and discoveries, etc. A set may



contain anywhere from ten to one thousand cards. With customary Teutonic thoroughness, Germany produces most of the higher numbered sets.

For those who are interested in this subject an inquiry of the hobby editor of any newspaper or hobby magazine will supply the required information as to how to build up a collection.

EUGENE W. BLANK

COLGATE-PALMOLIVE-PEET COMPANY
JERSEY CITY, NEW JERSEY

SEMI-MICRO ORGANIC TECHNIC

To the Editor

DEAR SIR:

The developments of the past few years have stimulated an interest in micro- and semi-micro procedures that is being felt in our educational institutions. A demand is being created for a new technic that must be given some consideration ultimately, at least, in our regular undergraduate courses.

About seven years ago at Purdue University, the organic division undertook the revision of the undergraduate course so as to meet, in some measure, this apparent need. Year by year the course has been revised, the amounts of chemicals decreased, the procedures improved, and the technic simplified until we are offering what approximates a semi-micro course in undergraduate organic chemistry. We have made a beginning, but there still remains much to be done.

The response relative to papers presented at recent chemical meetings is ample evidence that a number of instructors are keenly interested in these newer developments and their bearing upon our undergraduate instruction. A number have expressed their desire to coöperate on the preparation of a set of semi-micro procedures in organic chemistry. Feeling that there are doubtless many others who have a similar interest along these lines, the writer takes this opportunity to invite their coöperation.

During the coming summer, the writer plans to publish in planograph form the exercises as they have been developed in the organic laboratories at Purdue University. Those who desire to coöperate on the project are invited to use these manuals during the coming year, and make their contributions toward their revision. In the revised form, the manual will be published as a coöperative project. Those who are interested should communicate at an early date with the writer.

ED. F. DEGERING

PURDUE UNIVERSITY
LAFAYETTE, INDIANA

AUTOMATIC FILTERING SET-UP

DONALD H. WEST

L. L. Wright High School, Ironwood, Michigan

It is often necessary to prepare a quantity of a filtered solution such as limewater for the use of the chemistry class. When suction is not feasible or available the tedious task of keeping funnels full may be avoided by using the simple filtering arrangement shown in the accompanying diagram.

A two-liter flask is fitted with a two-holed stopper and two glass tubes. One of the tubes extends nearly to the bottom of the flask and is about a centimeter in inner diameter. For this a glass tube from a broken condenser may be used. The other tube is about four millimeters in inner diameter and extends into the flask only the length of the neck. Both tubes extend outward an inch or two from the stopper. It is convenient to have a short section of rubber tubing and a pinch clamp on the outer end of the smaller tube.

The flask is filled with the liquid to be filtered and, with the smaller tube closed, it is inverted over the funnel and suspended on a ring stand. The height is adjusted so that the tubes extend into the funnel below the upper edge of the filter paper. The small outlet tube is opened, and the funnel is then kept full automatically.

W. O. Brooks
A. T. Burtsell
R. K. Carleton
Tenney L. Davis
J. Howard Graham
B. Clifford Hendricks
J. W. Howard

ABSTRACTS

R. A. Baker, *Abstract Editor*

D. C. Lichtenwalner
Greta Oppe

C. M. Pruitt
Leopold Scheflan
A. A. Vernon
E. D. Walter
Mary Elvira Weeks
Sidney Weinhouse
G. H. Woollett

KEEPING UP WITH CHEMISTRY

Bichromates. Anon. *Chem. Industries*, **10**, 23–6 (Jan., 1937).—"Although the shoes on his feet, the clothes on his back, the buildings in which he lives and works, the car he drives, the golf club he swings, could not be save for bichromates, nevertheless to Mr. Man-on-the-Street they are not even a name he knows. Bichromates' place is in the wings, decidedly backstage.

"To the chemist, however, bichromates are powerful oxidizing agents. To the tanner they furnish the means of shortening an ancient, time-consuming operation. To the dry color manufacturer they are the primary material for yellows and greens; to the dyer, an indispensable mordant. The electroplater must have chromic acid, derived from sodium bichromate. The brass manufacturer brightens the color of his products with it. Few industrial chemicals, indeed, have wider application. Where once, the principal, indeed, the only, use of chromite ore was in the production of chrome chemicals, this now ranks a poor third. Metallurgical and refractory uses have expanded tremendously in the last two decades.

"No prospect of a chrome shortage threatens, but unfortunately commercially workable deposits of ore are all situated in the world's most inaccessible outposts—New Caledonia, Rhodesia, India, Russia, and Turkey. It has been aptly said, 'the chrome business has one foot in a railroad car, the other on a tramp steamer—this situation results in many economic and political problems which worry everyone but the steamship companies.'

"The element chromium was discovered in 1797 by Vauguelin, who named it from the Greek word chroma, which means color. The first chrome-bearing ore in the United States was found in 1810 on the Maryland-Pennsylvania boundary. As one of the producers has delighted to relate in the advertisements, one Isaac Tyson, a trained chemist, discovered that a stone he used to chock a cider barrel contained chrome ore. The Tyson Mining Company was formed, and ore from the Reed Mine near Jarrettsville, Maryland, was shipped abroad in large quantities. A year later (1828) Wood Mine was discovered in Lancaster County, Pennsylvania, but not until 1845 was the first plant for producing bichromate of potash built in Baltimore. Shipments from the Pennsylvania-Maryland area from 1827 to 1882 have been estimated at 250,000 tons of ore averaging about forty to sixty-three per cent. Cr_2O_3. About 1860 high-grade ore from Turkey killed the foreign markets for domestic ore, and between 1870 and 1880 our chromite mining almost vanished. Turkey was chrome headquarters until the development of the New Caledonian mines late in the 19th century." A. T. B.

For chemists only. Anon. *Ind. Bull. of Arthur D. Little, Inc.*, **124**, 3–4 (May, 1937).—The "onium" type compounds are finding useful applications at the present time, especially with cellulose. Very active onium compounds, in strong solution, are able to soften cotton or other forms of cellulose to complete liquidity. The oniums are variations of amm(onium) hydroxide or amm(onium) chloride, with organic radicals substituted for the hydrogens. If the nitrogen atom is replaced by an oxygen atom, the compounds are called oxoniums, or if a phosphorus atom, they are called phosphoniums, and so with sulfur, selenium, arsenic, and iodine and many others. The radicals may be methyls, ethyls, etc., but it is necessary in order to have great activity that at least one of the three be a "long chain," such as cetyl or lauryl. A typical cellulose solvent is tributyl ethyl ammonium hydroxide. These onium compounds are also effective in "ring" combinations, as in cetyl pyridinium bromide. The dye industry is also finding use for these onium compounds during the "stripping" and "mordanting" processes. The hydroxide forms are alkaline while the chloride, bromide, acetate, or sulfate are neutral. G. O.

Rising Sun. Anon. *Ind. Bull. of Arthur D. Little, Inc.*, **124**, 1 (May, 1937).—Japan probably led all countries in new chemical products in 1936, in chemicals made for the first time and in new plant construction. Intensive research in Japan created two new printing ink dyes, a non-coloring enamel, a new azo dye, a fumigant, a chemical for softening food, a smallpox vaccine, and a sleeping sickness serum. Tung oil was used for water-proofing rain coats. New methods were also announced for making Glauber's salt, for treating residual brines to yield potassium sulfate, and for the recovery of ninety-five per cent. of the potash content of molasses. One company, following a period of research, was reported ready to start commercial production of urea by a new process, another developed a process for preparing colloidal sulfur, and an experiment station was working on a project for tanning and dyeing rabbit skins by the use of acid color. G. O.

Casein paste paints. Anon. *Ind. Bull. of Arthur D. Little, Inc.*, **124**, 1–2 (May, 1937).—Several types of cold water paints have been available for a number of years, but none seem to be so readily accepted as casein paste paints which are acid dispersions of casein in which pigments are suspended. Unlike kalsomine and the powdered casein paints that can be dispersed in water, the casein paste paints are similar to oil paints. Last year two million gallons were marketed. The acid gels of casein-containing pigments will keep for weeks if properly covered, whereas the powdered must be used the same day. These paste paints compete with the cost of oil paints on the basis of 20–30 per cent. less cost, quicker drying, lack of fire hazard, more pleasant odor, and ability to use on damp surfaces. There is already some attempt to substitute gamma protein of soy beans for casein due to the rising price of casein. G. O.

Clouds on the chemical horizon? S. D. Kirkpatrick. *Chem. & Met. Eng.*, **44**, 180–1 (April, 1937).—Chemical industry has its roots in the six fundamental human needs for food, shelter, clothing, health, security, and transportation. These roots must be firmly planted in fertile soil, constantly renewed through research, efficiently cultivated by modern chemical engineering technology, wisely managed and ably financed by patient, progressive, capital. But the chemical plant will not grow without the sunshine of public confidence and support.

Clouds are beginning to appear on the chemical horizon, the largest of which is "Ignorance and Misunderstanding." Much publicity has been given the chemist which misrepresents the conditions under which he works and the objectives which he hopes to attain. Chemical industry has been pictured as in favor of war when the truth is it is opposed to war for selfish as well as humanitarian reasons—for the greatest advancements and profits have come from contributions to health and comfort rather than death and destruction.

To dispel these clouds chemical industry must undertake public education. If the public is correctly and constantly informed of what an industry is doing, its objectives as well as its accomplishments, a sympathetic interest is bound to be developed. J. W. H.

What every chemical worker should know about safety. J. S. Shaw. *Chem. & Met. Eng.*, **44**, 198–9 (April, 1937).—Here are the safety items every chemical worker should know.

1. He should be familiar with the location and use of water hydrants, safety shower baths, fire blankets, exits, fire-fighting equipment, and first-aid equipment.
2. He should keep in a safe and proper place any protective equipment (goggles, gloves, aprons, boots, gas masks) and frequently rehearse their use.
3. Exits should not be blocked at any time.
4. When going on work he should personally "line-up" the equipment with which he is working and see that all is going well.

5. On observing a liquid spill on the floor he should not look up until he has retreated to a point where there will be no danger of splashes into his eyes or on his body.
6. He should report at once any condition in equipment which indicates the process is not going correctly.
7. He should acquaint himself with the reasons for following the methods which are prescribed for him, but never experiment without authority.
8. On leaving his work he should fully familiarize his successor with the condition of the equipment and the status of the chemicals in process.
9. The chemical plant is no place for monkey business nor horse play. The practical joker may be a potential killer.
10. The chemical worker should appreciate the fact that safety is sacred and that the safest method is generally the best method. J. W. H.

APPARATUS, DEMONSTRATIONS, AND LABORATORY PRACTICE

The preparation of aluminum as a lecture experiment. R. SCHARF. *Z. phys. chem. Unterricht.*, **49,** 163–6 (July-August, 1936).—As cryolith has a melting point of 1000° which is not reached easily with school facilities it is better to use a 1:1 mixture of cryolith and aluminum fluoride which melts at 800°. An iron crucible is used because graphite and carbon crucibles are poor conductors of heat. Fifty grams of the mixture is placed in the crucible and heated by gas. An arc carbon is used as anode and attached through a cork to the metallic stand which supports the crucible. The crucible serves as the cathode. After the anode is immersed into the molten mixture the distance between the anode and the bottom of the crucible should not exceed a few millimeters. The current is measured on an ampere meter and should be about 8 amperes. About 5 to 6 grams of pure Al_2O_3 is added, and the crucible is closed with an asbestos plate, leaving an outlet for the hot gases and the flame. After an hour the current is shut off and the hot crucible is immersed in cold water for a few seconds, whereupon it is removed from the water and the mixture is allowed to solidify completely in the air. On turning over the crucible and applying a few strokes of a hammer the solidified melt will drop off the crucible. Many small balls of aluminum of diameters up to 2 millimeters will be noticeable. As 96,500 amp. sec. produce 1 gram equivalent = 27/3 = 9 grams of aluminum an electrolysis of one hour at 8 amperes is equal to 3600 × 8 = 28,800 amp. sec. corresponding to (9 × 28,800)/96,500 = 2.7 grams of aluminum. The industrial efficiency is 65%, corresponding to 1.8 grams of aluminum. Such good results can hardly be expected, however, in this experiment. L. S.

The preparation of rayon according to the copper method. R. SCHARF. *Z. physik. chem. Unterricht.*, **50,** 21–2 (Jan.-Feb., 1937).—The method of preparation described in *Z. physik. chem. Unterricht*, **49,** 119 (1936) can be improved as follows. To 30 cc. of ammonium chloride solution containing 25% ammonia (sp. gr. 0.9) in a flask add 0.7 g. cuprous hydroxide and some cotton, and close with a cork stopper. Add more cuprous hydroxide at the same rate at which the cellulose reacts with the copper. Shake frequently with care without letting any air bubbles form. When the solution has become uniform after $^1/_2$–1 hour begin the spinning operation as described in the earlier article. If the thread coming from the nozzle is removed at once from the bath threads can be obtained which are free from knots and which are several meters long. After the threads have been rinsed twice they can be dried without any additional treatment. L. S.

Ethyl chloride. E. EBERHART. *Z. physik. chem. Unterricht.*, **50,** 66 (Mar.-Apr., 1937).—Although ethyl chloride, as representative of alkyl halides, can be prepared easily by the action of chlorine and phosphorus on ethyl alcohol it is better to use the reaction

$$C_2H_5OH + HCl = C_2H_5Cl + HO,$$

as ethyl chloride is so different physically from ethyl alcohol, thus demonstrating very definitely that ethyl alcohol and hydrochloric acid have produced a new compound. To prepare ethyl chloride by this method saturate 50–100 cc. of ethyl alcohol with dry hydrochloric acid gas prepared in the usual manner from fuming hydrochloric acid and concentrated sulfuric acid. Add anhydrous zinc chloride and distil, collecting the product in an ice-cooled receiver. The distillate can be tested by allowing a little to evaporate in one's hand and by freezing water in a watch glass. The experiment can be performed in one lecture period. L. S.

SCIENTIFIC REVIEWS AND BIBLIOGRAPHIES; TABULATIONS OF SCIENTIFIC DATA

Potato starch and the products of its refining. W. DÖRFELDT. *Chem.-Ztg.*, **61,** 113–5 (Feb. 3, 1937).—A review dealing with the manufacture of potato starch, its uses and its refining. L. S.

The allotropism of chemical elements. A. SCHULZE. *Chem.-Ztg.*, **61,** 87–90 (Jan. 23, 1937); 108–10 (Jan. 30, 1937).—A review covering allotropic forms of a large number of elements. L. S.

Naphthalene and its modern uses. F. SCHUSTER. *Chem.-Ztg.*, **61,** 133–4 (Feb. 4, 1937).—A survey. L. S.

The vitamin B group. E. DANE. *Chem.-Ztg.*, **61,** 145–8 (Feb. 13, 1937).—A review dealing with the following subjects. B_1: biological detection, occurrence, preparation, constitution, mechanism of physiological action. B_2: action, occurrence and detection, constitution, and synthesis. A brief description of B_3–B_6 is included. L. S.

The development of macromolecular chemistry. H. STAUDINGER. *Chem.-Ztg.*, **61,** 14–5 (Jan. 2, 1937).—A review. L. S.

The history of the manufacture of highly concentrated nitric acid according to the electric arc method. H. PAULING. *Chem.-Ztg.*, **61,** 5–6 (Jan. 2, 1937).—A review. L. S.

Organic chemical discoveries and their importance in the present and in the future. O. DIELS. *Chem.-Ztg.*, **61,** 7–8 (Jan. 2, 1937).—A review dealing with carbon suboxide O=C=C=C=O, diene syntheses, and selenium dehydration. L. S.

Progress in the field of caoutchouc and its synthetic substitutes. F. KIRCHHOF. *Chem.-Ztg.*, **60,** 721–5 (Sept. 2, 1936); 745–6 (Sept. 9, 1936).—A review of the following subjects: the culture and production of crude rubber, latex chemistry and technology, powdered caoutchouc, softened rubber, progress in the mechanical treatment of caoutchouc, chemical and physical structure of natural caoutchouc and related compounds (raw caoutchouc, structure of vulcanized caoutchouc), new synthetic caoutchoucs and caoutchouc substitutes (preparation of Buna caoutchouc, chemical structure of the new synthetic caoutchoucs, properties and uses of the synthetic caoutchoucs), synthetic caoutchouc in Russia, DuPrene, thiokols. Twenty-six references. L. S.

Calcium. A. SCHULZE. *Chem.-Ztg.*, **60,** 733–5 (Sept. 5, 1936).—A review of the preparation, properties, and uses of calcium. Many references. L. S.

Fluorine and its compounds. O. RUFF. *Chem.-Ztg.*, **60,** 873–4 (Oct. 24, 1936).—An address. L. S.

Three decennials of enzyme chemistry. H. v. EULER. *Chem.-Ztg.*, **61,** 15–6 (Jan. 2, 1937).—A review. L. S.

Chemical aids in organic syntheses. R. KUHN. *Chem.-Ztg.*, **61,** 17–8 (Jan. 2, 1937).—A review covering the use of lead oxide, a trace of acid, ammonium chloride, and boric acid in organic syntheses. L. S.

The synthesis of nitric acid by ammonia combustion. E. BRAUER. *Chem.-Ztg.*, **61,** 19–20 (Jan. 2, 1937).—A review. L. S.

The historical development of the hardening of fats. W. NORMANN. *Chem.-Ztg.*, **61,** 20–2 (Jan. 2, 1937).—A review. L. S.

The discovery of radiothor and mesothor. O. HAHN. *Chem.-Ztg.*, **61,** 22 (Jan. 2, 1937).—A review. L. S.

My contribution to the chemistry of molecular compounds. P. PFEIFFER. *Chem.-Ztg.*, **61,** 22–3 (Jan. 2, 1937).—A review. L. S.

How a discovery was made. P. WALDEN. *Chem.-Ztg.*, **61,** 9–10 (Jan. 2, 1937).—A description of the discovery of the Walden inversion. L. S.

RECENT BOOKS

THE BIOCHEMISTRY OF THE LIPIDS. *Henry B. Bull, Ph.D.*, formerly Assistant Professor of Agricultural Biochemistry, University of Minnesota. At present Assistant Professor of Physiological Chemistry, Northwestern University Medical School, Chicago, Illinois. John Wiley and Sons, Inc., New York City, 1937. ix + 169 pp. 63 figs. 15 × 23 cm. $2.75.

In writing this "rearrangement, a rewriting and extension" of an earlier mimeographed book, the author, with "the needs of the graduate students in biochemistry constantly in mind," wished to produce not a "technology and dictionary of fats and oils," but "an up-to-date, readable textbook which would attempt to gain some insight into the chemistry and physiology of the lipids."

The author adopts Bloor's classification and definition of lipids, *viz.:*

I. Simple lipids—(*a*) fats, (*b*) waxes
II. Compound lipids—(*a*) phospholipids, (*b*) cerebrosides, (*c*) aminolipids, (*d*) sulfolipids
III. Derived lipids—(*a*) fatty acids, (*b*) sterols, (*c*) alcohols

and accordingly has divided his treatment under the following chapter headings.

Introduction and Classification

I. The Fatty Acids
II. The Soaps
III. Alcohols, Waxes, and Hydrocarbons
IV. The Sterols and Related Compounds
V. Fats and Oils
VI. The Phospholipids
VII. Cerebrosides
VIII. Carbohydrate Esters of the Higher Fatty Acids
IX. Emulsions
Author Index
Subject Index

The author makes no claim for encyclopedic completeness. Doubtless he was tempted at many points to expand greatly his treatise; *e. g.*, the chapter on sterols must have been an open invitation to prepare an extended résumé of this newly explored and highly fascinating field. Yet he shows commendable restraint and brings this interesting subject into focus only sufficiently to show its importance and relationship to his main topic. Other examples of similar nature might be given. With its numerous and strategic references, the book leaves with the reader an impression that the material is well and adequately presented.

The development of the subject matter, as well as its method of presentation, serves to call attention to and emphasize a very important subdivision of the larger realm of biochemistry.

WALTER H. HARTUNG

SCHOOL OF PHARMACY
UNIVERSITY OF MARYLAND
BALTIMORE, MARYLAND

LABORATORY MANUAL OF INORGANIC CHEMISTRY AND ELEMENTARY QUALITATIVE ANALYSIS. *C. C. Hedges*, Head of Department of Chemistry and Chemical Engineering, and *H. R. Brayton*, Professor of Inorganic Chemistry, The Agricultural and Mechanical College of Texas. D. C. Heath and Company, New York City, 1937. vii + 264 pp. 15.5 × 24.5 cm. $1.48.

This manual is entirely devoted to laboratory exercises and related written work, and covers sufficient material for an entire year. General inorganic chemistry (one hundred fifteen exercises), introduction to qualitative analysis through reactions of metallic ions (twenty-four exercises), and qualitative analysis for the common cations and anions are all included. The qualitative procedure is presented by means of diagrams, and divides the cations into chloride, hydrogen sulfide, ammonium polysulfide, ammonium hydroxide, ammonium sulfide, ammonium carbonate, and alkali groups. Tests are given for ten common anions, and a phosphate modification is described.

The manual is designed to be used as follows. Answers to questions are written directly on the page bearing the laboratory directions, the page is torn out, handed in for correction, and then filed by the student in a loose-leaf binder. This system should give marked flexibility in choice of exercises without sacrifice of compactness.

No theoretical material is presented in the manual, but emphasis is placed very early on nomenclature, formula and equation writing, and problem work, for which an unusual amount of drill material is included in the manual. This material seems to be well chosen, unless there is objection to the exclusive use of molecular equations. It is the evident intention of the authors that the material in the manual be supplemented to a considerable extent by oral instruction.

Simultaneous treatment of study topics in lecture and laboratory is emphasized, and is facilitated by the detachable nature of all the pages of the manual. An interesting feature is the inclusion of a number of tests of substances commonly encountered in industrial practice.

The makeup is good, the content is orthodox, and the manual should prove very satisfactory when used as the authors intend.

LOTHROP SMITH

STATE UNIVERSITY OF IOWA
IOWA CITY, IOWA

CHEMICAL PRINCIPLES with Particular Application to Qualitative Analysis. *John H. Yoe, Ph.D.*, Professor of Chemistry, University of Virginia. John Wiley & Sons, Inc., New York City, 1937. ix + 311 pp. 29 figs. 23 tables. 15 × 23 cm. $2.75.

This text was written with the primary purpose of presenting the fundamental principles of chemistry necessary to an understanding of the procedures of qualitative analysis and other branches of the subject which usually confront the student in passing from general chemistry to physical chemistry. Many of the topics discussed are likewise applicable to quantitative analysis as it is usually presented. Special emphasis is placed upon the application of the principles of chemical equilibrium to qualitative analysis. With the exception of a brief outline of dry methods of analysis given in the appendix, the text does not contain any laboratory procedures or discussions of the chemistry of the common positive and negative ions. It is expected that the text will be used to support laboratory manuals of qualitative analysis which are now available on the market. To this extent the author has succeeded in an admirable manner. The text is well written, the principles are clearly and fully presented, numerous problems and examples of problems relating to chemical equilibrium are given, and, in general, the text is comprehensive in its scope.

The first four chapters of the text are devoted to fundamental laws usually given in a general chemistry course and are intended by the author to serve as a review and an introduction. Chapter V contains a brief introduction to oxidation and reduction and gives methods for the balancing of equations. Chapters VI and VII deal with the properties of gases and liquids, respectively. The following topics are then presented in order: the properties of solids; the properties of solutions; solutions of electrolytes; interionic attraction theory; homogeneous equilibrium; the

law of mass action; heterogeneous equilibrium; the solubility-product principle; co-precipitation; units used for equilibrium expressions; equilibrium calculations, with special reference to weak acids and weak bases and the common-ion effect; solubility-product calculations, the dissolving of precipitates; Werner's coördination theory and complex ions; neutralization and hydrolysis with reference to equilibrium calculations, the pH scale, buffered solutions, and titration; oxidation-reduction equilibria from the standpoint of standard and concentration cells; chemical kinetics, the order of reactions, catalysts; thermochemistry, electrochemistry and photochemistry; the electrical theory of matter, radioactivity, and atomic structure; and the properties of colloids.

The text is well supported by numerous examples of all types of equilibrium calculations. In addition, it contains about three hundred problems involving, for the most part, equilibrium calculations. Answers are also given for many of these problems. Tables of ionization, solubility-product, and other equilibrium constants are placed in appropriate sections of the text.

It is unfortunate that strong electrolytes are treated as partially ionized in aqueous solutions. It would appear that, in light of the modern theories of electrolytes, it would be more advisable to treat strong electrolytes as being completely ionized. Such a procedure would also have the advantage of simplifying the treatment of ionic equilibria for the beginning student.

The text is one of the most comprehensive in its field and should serve as a very valuable aid to the teacher in the presentation of qualitative analysis and other subjects which engage the student in passing from general chemistry to physical chemistry. It well deserves serious consideration by every teacher interested in this field of chemistry. In addition, more advanced students of chemistry will find it a valuable tool for problems of chemical and ionic equilibria.

WARREN C. JOHNSON

UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS

QUANTITATIVE PHARMACEUTICAL CHEMISTRY. *Glenn L. Jenkins*, University of Minnesota, and *Andrew G. DuMez*, University of Maryland. 2nd ed. McGraw-Hill Book Company, Inc., New York City, 1937. xxv + 466 pp. 67 figs. 13.5 × 20 cm. $3.50.

The contents of the second edition have been arranged in three parts instead of four. While the authors state that theory has been brought up-to-date, it may be said with reasonable fairness that perhaps the text is still a bit one of procedure rather than one of the theory underlying these procedures. This is a common criticism of most texts in the fundamental sciences written for any special group. This does not mean that in the hands of a competent instructor this book may not be used to great advantage.

Inasmuch as practically all students using this text will go into one of the health service professions, it is, with the single criticism offered above, admirably adapted to the use of such groups.

WORTLEY F. RUDD

MEDICAL COLLEGE OF VIRGINIA
RICHMOND, VIRGINIA

AN INTRODUCTION TO COLLEGE CHEMISTRY. *Herman T. Briscoe*, Professor of Chemistry, Indiana University. Houghton Mifflin Company, New York City, 1937. vi + 653 pp. 242 figs. 15 × 23.5 cm. $3.00.

Professor Briscoe has produced a very readable text which is representative of the changing philosophy of chemical education at the college level. With great emphasis upon principles he has, from the beginning, thoroughly interwoven recent theories of structure and change into the conventional pattern of general chemistry.

The text is an excellent introduction to theoretical chemistry, particularly for students who have already had a preparatory course. It represents a distinct advance in the use of ionic equations involving solid substances and lends courage to those who advocate starting the elementary course with electrochemistry. Equally praiseworthy is the treatment of the gas laws, equilibrium, radioactivity, and the colloidal state.

Most of the forty-seven chapters are followed by references for further reading and by sets of review questions which refer almost wholly to the text.

In his zeal to develop the theoretical side, the author has sacrificed a considerable amount of conventional descriptive chemistry, and, unfortunately, the remaining portions do not measure up. There is a definite lack of homogeneity, and, in some cases, there are striking inaccuracies.

In introducing each element, the author evidently intends to present the economic background, but in one case he may refer only to the abundance in the earth's crust, in another to the world production, or to the U. S. production, or to the U. S. requirement or value, etc., with the result that the composite picture is blurred. After emphasizing the properties of substances, the author is prone to list the important uses without relating them to the properties upon which they depend (hydrogen, pp. 101–3; sulfuric acid, pp. 407–8).

The molecule is defined (p. 38) as "the smallest particle that occurs in the free natural state of the substance and that shows all of the properties of the substance," leaving the student to visualize the hardness, melting point, and boiling point of a single molecule.

In a text bearing the copyright date 1937, one wonders why Carson's "Aluminum and Its Alloys" (1926) should be the most recent book reference in this amazingly active field, or why the latest periodical reference on the same subject should be 1930.

The author is content to quote 100,000 tons as his latest figure (1929) for the quantity of fuel produced by the Bergius process for liquefying coal. Yet this figure has been mounting steadily and was reported to be 900,000 tons for Germany alone in 1935.

With reference to carbon tetrachloride, this statement appears (p. 227). "A pyrene extinguisher is filled with it." As a matter of fact, while the liquid known as pyrene does contain a considerable percentage of carbon tetrachloride, the former freezes at −49°C. and the latter at −23°C. Incidentally, in connection with firefoam and other commercial fire extinguishers, no mention is made of "Phomaire" and liquid carbon dioxide which have achieved astonishing success in recent years.

The arc process is pictured as being successfully employed in Norway at the present time, in spite of the fact that it has been persistently reported as obsolete in that country since 1930.

Minor points which may be attributed to carelessness are typefied by the omission of several titles of references to periodicals (p. 441); quoting −32° as the melting point of mercury (p. 15); a diagram showing five-valence electrons for the chlorine atom (p. 179); the equation (p. 53) indicating that Fe_2O_3 is the product of burning iron in pure oxygen; the omission of the units of measurement in Figure 121 (p. 236) and the omission of publishers' copyright dates in all except the first of the list of references. Mention should also be made of the frequent use of terms before they are defined. One naturally turns to the index in such an emergency, only to find that the index is incomplete (chemical property, physical property, critical temperature missing).

These errors will undoubtedly be ironed out in subsequent editions.

The author's style is delightfully convincing. The diagrams, charts, and illustrations are well chosen, the print clear, and the binding excellent.

ROSS A. BAKER

COLLEGE OF THE CITY OF NEW YORK
NEW YORK CITY

ELEMENTARY CHEMISTRY. *D. G. Hill, J. H. Saylor, W. C. Vosburgh, R. N. Wilson*, Duke University. 3rd edition. Henry Holt & Co., Inc., New York City, 1937. vi + 473 pp. 68 figs. 44 tables. 14 × 22 cm. $2.80.

Here is a book in which there is much meat and very little cake. The authors state, "One of the objectives in writing this book was to present modern electrolyte theory in simple terms and make use of the modern theory of atomic structure." They have succeeded in many ways in giving an excellent résumé of current theories. This is no easy task when the description must be kept within the scope of elementary chemistry.

There is much which the reviewer has found to commend.

Opinions differ as to the order of presentation of subject matter and the text could be used by other colleges where selected assignments are made. The subject of solutions is delayed until Chapter XIV (there being thirty chapters in all); whereas a general chapter on the metals is introduced in Chapter IX.

Organic chemistry is the subject of four chapters—almost one-seventh of the textual matter, a good portion of which is featured by structural formulas.

Le Chatelier's principle is introduced early in Chapter II, where it is used to explain the behavior of an ice and water system. The subject of molecular weights in Chapter IV, the structure of the hydrogen atom in Chapter V, crystal structure in Chapter VIII, and freezing points of solutions in Chapter XIV are all well done.

The presentation of calculations based on equations in Chapter VI is unique.

There are a few questions which arise as one reads the text. Would the beginning student be instructed and inspired by more pictures and diagrams? Should not a little more historical matter be introduced? At least the names of great investigators in the fields of radioactivity, the colloidal state, heavy water, etc., should be mentioned. Is there sufficient instruction included in the balancing of equations? It would seem that the authors might have stressed the electronic method here to supplement their views on atomic structure. Would it not be well to stress important laws and principles in heavy or italicized type? In the table of alloys, would Cu–Pb be considered a bronze; and what sort of pewter is represented as Cu, 65; Zn, 32; Pb; Sn?

Most of the above shortcomings can be met by good supplementary lectures, where charts, demonstrations, and historical developments are presented.

Older teachers will balk at the new style ionic equations, and the definitions of acids and bases in terms of proton donors and proton acceptors. However, the Brønsted-La Mer school has been forging ahead, and as the authors state, "Changes in definitions are inevitable in a science that is growing, and is a sign of progress. The attendant confusion is less of an evil than would be the resistance to progress if new definitions could not be made when needed."

Chapters are accompanied by excellent questions and references for additional reading. The glossary at the end of the book is a good feature, which might be further amplified in future editions.

The book is well printed and bound; the price is attractive.

R. D. BILLINGER

LEHIGH UNIVERSITY
BETHLEHEM, PENNSYLVANIA

THE LITTLE THINGS IN LIFE. *Barnett Sure, Ph.D.*, University of Arkansas. D. Appleton-Century Company, Inc., New York City, 1937. xi + 340 pp. 13.5 × 20.5 cm. $2.50.

The purpose of this book is to present, in non-technical language, "the story of the vitamins, mineral elements and ductless glands, in relation to nutrition and health of man." The author states that he has endeavored to stress the applications of scientific research to human problems and has purposely endeavored to minimize the laboratory phases so far as experimental animals are concerned.

The book is written for the lay reader in a clear and pleasing style that should appeal to non-technical readers. On the other hand, the reviewer feels that the book can be read with pleasure and profit by physicians and students of nutrition for the reason the author deals with many subjects which do not ordinarily come to the attention of the busy specialist.

Chapter I deals with deficiency diseases such as scurvy, Barlow's disease, rickets, and beriberi, with special reference to cause and dietary treatment.

Chapter II, entitled "The Vitamins," gives a brief historical résumé of the discovery of vitamins accompanied by a discussion of their occurrence, functions, properties, and stability. Theoretical and controversial topics are avoided quite successfully, and practical questions of interest to the layman are stressed.

Chapter III is devoted to a brief discussion of "Vitamins and Dental Disorders" while Chapter IV gives a brief discussion of "The Relation of Vitamin Deficiencies to Colds and Infections."

Chapter V treats of "Vitamins in Infant Nutrition" which is followed (Chapter VI) by a discussion of "Vitamins during the Nursing Period and Pregnancy."

Subsequent chapters (VII to XIV inclusive) deal with such topics as "Vitamins and Malnutrition," "Vitamins in Various Ailments," "Vitamin Content of Foodstuffs," "Minerals, Anemias and Goiter," "Foods, Hay-Fever and Asthma," "Ferments and Indigestion," "The Ductless Glands and Nutrition," and "The Little Things of Life Are the Big Things of Life."

Five pages at the end of the book are devoted to a glossary which gives simple definitions for technical terms used in the preceding chapters. Author and subject indices are also appended. The reviewer infers that this book is to be included in the Appleton Popular Health Series to which many eminent popular writers on health and medical topics have contributed.

Dr. Sure writes with authority in the vitamin field, in which he has made many important contributions. He writes convincingly in related fields, in which he has done little or no experimental work. In the reviewer's opinion Dr. Sure has done a remarkably good job in reviewing the clinical field, where he has had little or no first-hand experience. It is entirely probable that some members of the medical fraternity will feel that Dr. Sure has overstepped, at times, that debatable zone between biochemistry and medicine which has been guarded somewhat jealously by the medical profession. In most cases, however, the author defends his position by direct references to the original experimental and clinical literature.

The reviewer knows of no popular treatise which discusses the topics enumerated with greater clarity and interest.

THE PENNSYLVANIA STATE COLLEGE
STATE COLLEGE, PENNSYLVANIA

R. ADAMS DUTCHER

THE CHEMISTRY OF NATURAL PRODUCTS RELATED TO PHENANTHRENE. *L. F. Fieser*. A. C. S. Monograph Series No. 70. 2nd ed. xiv + 456 pp. 15 × 23 cm. Reinhold Publishing Corporation, New York City. $7.00.

The general interest in the subject matter presented in this monograph is well demonstrated by the need for a second edition within a year after the appearance of the first edition. The rapid tempo at which investigations falling within the scope of this book are forthcoming has also made it desirable to bring out a second edition so shortly after the first one. During the comparatively short period of one year, over three hundred additional papers have been published either on the chemical or on the biological aspects of the various derivatives of phenanthrene.

The author did not attempt to make an extensive revision of the original text but confined himself to adding an appendix of ninety-one pages in which he has given an excellent critical survey of the further scientific advances made in this field of research during the past year. The discussion of the numerous papers published is more condensed in the appendix than in the original text; however, the clarity of presentation did not suffer. One may, perhaps, regret that the author desisted from employing structural formulas for illustration in the appendix as he has done so freely in the text. The appendix includes references to papers bearing publication data up to January 1, 1937.

The extent of the progress made during the past year in the chemical and biological investigations on the various compounds containing the phenanthrene ring structure may perhaps be best indicated by the number of pages allowed for each section, as follows: Sterol and Bile Acids, twenty-five pages; Sex Hormones, twenty-six pages; Heart Poisons, fifteen pages; Saponins, eight pages; while the remaining three chapters require five to eight pages each.

The revised edition will be of great interest and profit to those who desire to become better acquainted with the established facts and with the various still-unsolved questions in this important phase of biological chemistry.

Reprints of the appendix with the revised index are available at one dollar to purchasers of the first edition.

JOHNS HOPKINS UNIVERSITY
BALTIMORE, MARYLAND

HANS JENSEN

Series of Organic Compounds

To demonstrate similarity in reactions of homologues... to show the properties of straight or branched chains... to indicate the effect of substituted groups in various positions. These are some of the uses for which complete series of organic compounds are valuable.

Included among the 3,100 compounds in List No. 28 of *Eastman Organic Chemicals* are many such series of both aromatic and aliphatic groups. A free copy of this list will be forwarded upon request. Eastman Kodak Company, *Chemical Sales Division,* Rochester, N. Y.

EASTMAN ORGANIC CHEMICALS

Progressive Books on Chemistry

FOWLES—Lecture Experiments in Chemistry

150 Illustrations. Tables. Appendices. $5.00

By G. Fowles, M.Sc., A.I.C., F.C.S. (Latymer Upper School, Hammersmith)

It is a book for teachers, with over 600 experiments. They are placed against a background of teaching motives and methods. Clear instructions for carrying out each method are given.

WERTHEIM—Laboratory Guide for Organic Chemistry

24 Illustrations. 524 Pages. $2.00

By E. Wertheim (University of Arkansas)

It presents experimental material for a year's course in elementary organic chemistry. It is especially designed for those majoring in chemistry and for premedical and engineering students.

BAILEY & CADY—Qualitative Analysis, 10th Edition

322 Pages. $2.00

By E. H. S. Bailey and Hamilton Cady. Revised by A. W. Davidson, Ph.D. (Univ. of Kansas)

A brief summary of the important principles of typical reactions. Complete and accurate directions are provided.

POPOFF—Quantitative Analysis, 3rd Edition

75 Illustrations. 555 Pages. $4.00

By S. Popoff. Revised by M. J. Rice and W. P. Cortelyou (Alfred Univ.)

It contains material for both elementary and advanced courses. The order of presentation is theory, calculations, laboratory.

MULDOON—Textbook of Organic Chemistry

For Students of the Medical Sciences. 2d Edition

33 Illustrations. 590 Pages. $3.00

By H. P. Muldoon, D.Sc. (Duquesne Univ.)

It is for premedical courses and emphasizes close relationship of organic chemistry with other branches of science. A laboratory manual has been prepared to accompany this text ($1.25).

P. BLAKISTON'S SON & CO., Inc. 1012 Walnut Street Philadelphia, Pa.

TRADE ANNOUNCEMENTS

Du Pont Announces New Chemical for Flame-Proofing Textile Fabrics

A new flame-proofing agent for textiles and paper just developed by the *du Pont Company* was demonstrated on Wednesday evening, March 31st, at the *du Pont* Exhibition which is being held under the auspices of the Museum of Science and Industry in New York City. Textiles and paper treated with this new chemical are highly flame-proof, and at the same time have a soft, pleasing "feel." In addition, this new chemical does not have any appreciable influence on the strength of textiles and paper, or on the dyestuffs commonly used. In announcing this new chemical, it is pointed out that textiles and paper treated with fire retardants are not fire-proof in the sense that they cannot be burned, but are flame-proof in that they do not blaze or smolder, and accordingly will not spread a fire.

During recent years much research has been directed to the development of a satisfactory flame-proofing agent for textiles and paper, but up to the present all materials used for this purpose have had certain disadvantages which limited their usefulness.

The *du Pont Company* expects to begin the manufacture of this new material on a commercial scale in the near future.

Abridged Spectrophotometer

The new Aminco Type "V" Photometer, an abridged photoelectric spectrophotometer, is adapted to almost any chemical analysis where colorimetric methods may be developed. Its accuracy and reproducibility of results are far greater than can be achieved by visual methods.

When furnished with an 85-watt mercury-vapor lamp and suitable filters it isolates the various lines of mercury radiation. For work involving wave-lengths that cannot be obtained from a mercury-vapor lamp, the Aminco Photometer can be used with a 50-watt incandescent lamp and suitable filters for isolating the wavelength bands that are needed. Even with no filters, this instrument is more sensitive to color intensity difference than the human eye, and gives more surely reproducible results than can be obtained with most visual colorimeters.

For general laboratory use, the Aminco Photometer, equipped with a double set of red, yellow, blue, green, and violet filters, is far more accurate and adaptable than a visual colorimeter, and when once calibrated for a particular material, the calibration is permanent and there is no necessity for making up standard solutions when the instrument is used on the same material later.

For use on 110–120 volts, 40–60 cycles, A.C., also for use on D.C. when used with suitable converter. Weight, 16 lb., measure $13'' \times 13'' - \times 9''$ overall.

Bulletin 842-CE is available. The Photometer is made by *American Instrument Company, Inc., 8010–8020 Georgia Avenue, Silver Spring, Maryland.*

To Keep Culture-Media from Drying Out

One of the problems of the small clinical laboratory and only a lesser problem in other laboratories is that of keeping culture-media ready for use, particularly Loeffler's medium, blood-agar slants and blood-agar plates. For this purpose and for preservation of stock cultures a material called Parafilm (made by the *Marathon Paper Mills Co., Rothschild, Wisconsin*) is recommended [*cf.*, M. C. TERRY, *Science*, **85**, 319–20 (1937)]. A square of this film pressed down on the mouth of a culture tube, the cotton plug having first been pushed in, keeps the slant from drying out for weeks at incubator temperature and indefinitely at room temperature. It is equally efficient in keeping the volume of a broth tube or flask unchanged. The advantage over wax or paraffin is that the seal is readily stripped off, and the cotton plug remains perfectly manageable. The security of the seal may be seen in the following experiment: (1) 10 cc. of alcohol in a graduated centrifuge tube lost nothing in volume in four days, during which time the same quantity in a cotton-stoppered tube, both in the 37° incubator, went down to 7 cc.; (2) a tube of water at 54° kept the level unchanged for nine days, during which time the control went down an inch.

"Lightnin" Mixer

Powered by a $^1/_{33}$ H.P., totally enclosed, air-jacketed, and fan-cooled repulsion-induction type motor, this mixer duplicates on a laboratory scale the actual work of large-scale production. It is furnished in 110–220 volt, 50 or 60 cycle single phase only. While essentially a laboratory unit, numerous uses have been found for this unit on small full-scale production. It is ruggedly built and designed for continuous duty operation at full load at a low operating temperature. Shaft and propeller are furnished either in stainless steel or monel metal. Wing nuts permit numerous adjustments to produce a wide variety of mixing actions.

The Model "L" is furnished with monel tube and chuck which permit five inches of shaft adjustment. The housing is equipped with an oilless outboard bearing and is tapered for insertion in small neck bottles or jugs. This mixer can be equipped with folding propellers which open by centrifugal force after insertion into small openings. It can also be fitted with a bung-hole adaptor. The weight complete is slightly under seven pounds. It is manufactured by the *Mixing Equipment Company, Inc., 1062 Garson Avenue, Rochester, New York.*

400-Watt Combination Mercury-Incandescent Lighting Units

For applications of industrial lighting where color correction is desired, the *Westinghouse* combination unit effectively and efficiently mixes the light lumens of the 400-Watt High Intensity Mercury Lamp with a quantity of light lumens from incandescent lamps. It is designed for use on mounting heights of 12 to 18 feet. The spacing should not exceed $1^1/_4$ times the mounting height.

Two distinct circuits are used, one to control the mercury lamp and one to control the incandescent lamps. The design is such as to allow three lamps, not over 150 watts each, to be used without interfering with the restarting of the mercury lamp in case of a voltage interruption.

The complete unit consists of an aluminum reflector with socket assembly and a monax diffusing banded glass bowl. The reflector is made from #14 gage etching grade aluminum sheet. The entire socket assembly, which consists of three medium sockets for the incandescent lamps symmetrically spaced about the special skeleton socket for the mercury lamp, are attached directly to the top of the reflector. A slip type louvered cover provides sufficient ventilation for the sockets and allows for wiring or inspection of wiring after reflector is hung. It is arranged for mounting on $^1/_2''$ conduit.

The diffusing bowl is banded at the fitter and hinged in the reflector. A simple catch locks globe securely in position. A heavy felt gasket provides a dust-tight joint between the glass and reflector.

The entire assembly is simple to wire and the hinged bowl provides for quick and easy access to the lamps and eliminates the hazards of removing large globes. Sufficient ventilation for the lamp bases and sockets is provided to keep the temperature within safe operating limits. Entire aluminum reflector and louvers are finished by the Alzac process for greater permanence and ease of cleaning.